Proceedings of the American Academy of Arts and Sciences

Vol. 81, No. 2, P. 33-100, January, 1952

BIOGRAPHICAL DIGESTS IV: CENTENNIALS AND POLYCENTENNIALS DURING 1952 WITH INTEREST FOR CHEMISTS AND PHYSICISTS

Ernest H. Huntress
Massachusetts Institute of Technology

BIOGRAPHICAL DIGESTS IV: CENTENNIALS AND POLYCENTENNIALS DURING 1952 WITH INTEREST FOR CHEMISTS AND PHYSICISTS

Ernest H. Huntress
Massachusetts Institute of Technology
Cambridge, Massachusetts

The present paper represents the fourth in a series of biographical digests of distinguished chemists, physicists, and other scientists conceived some years ago[1] and more specifically implemented in the present form during this and the three preceding years.[2] This unique approach has proved so useful and has attracted such wide attention that its extension to fields other than science is recommended. Attention is directed to the citations following most of the individual digests. These are restricted to material in the periodical literature and are arranged in a sequence of diminishing merit as arbitrarily judged by this writer. When book biographies of a particular individual exist these are often mentioned in the text of the digests.

The same simple notational methods previously explained are continued and the chronological occurrence of the several anniversaries is tabulated, but in order to facilitate easy reference to individual subjects the corresponding sketches have been placed in alphabetical sequence. In view of the substantial collection of these digests now available a cumulative name index including all subjects treated in this paper together with its three precursors has been supplied.

In view of inevitable limitations of time and space, the subjects of these biographical digests have been selected from a host. Among those for whom detailed treatment cannot be presented here the following may be mentioned: Luigi Balbiano (1852-1917), the Italian organic chemist; Maximilian Eugen

[1] Huntress, J. Chem. Education *14,* 328-344 (1937).

[2] a. Huntress, Biographical Digests: I (for 1949), Proc. Am. Acad. Arts Sci. *77,* 33-54 (1949); b. II (for 1950), *ibid. 78,* 1-35 (1950); c. III (for 1951), *ibid. 79,* 3-44 (1951).

Hermann Dennstedt (1852-1931), German analytical and forensic chemist; Robert Gnehm (1852-1926), dyestuff chemist of Switzerland; Alfred John Greenaway (1852-1938), British chemist and former editor of the Journal of the Chemical Society of London; John Griscom (1774-1852), early American chemist; Josef Emmanuel Hibsch (1852-1940), German mineralogist and geologist; Wilhelm Hisinger (1766-1852), Swedish geologist and mineralogist; Gerardus Johannes Mulder (1802-1880), Dutch biochemist; Franz Oppenheim (1852-1929), German industrial chemist; Carl von Rechenberg (1852-1926), German distillation expert; Eberhard Rimbach (1852-1933), German chemist; Eduard Vongerichten (1852-1930), German chemist; and Leonardo da Vinci (1452-1519), Italian artist, engineer, inventor, and scientist. Although the last lies somewhat beyond the scope of the present series, attention is called to the fact that 1952 represents the 500th anniversary of da Vinci's birth.

Of the twenty-eight subjects comprising this treatment for 1952, twenty-one represent 100th anniversaries, five 150th memorials, with one 200th and one 350th commemoration. From the geographical viewpoint they are distributed among the following countries: Great Britain 7, France 7, Germany 6, United States 4, with one each from Finland, Holland, Russia, and Spain.

Memorial Dates During 1951

Jan.	1	Centenary of birth of E. A. Demarcay
Jan.	5	Centenary of birth of A. L. Étard
Jan.	9	Centenary of birth of W. H. Nichols
Feb.	2	Sesquicentenary of birth of J. B. Boussingault
Feb.	6	Sesquicentenary of birth of (Sir) Charles Wheatstone
Mar.	10	Centenary of birth of R. Anschütz
Apr.	14	Centenary of birth of J. M. Stillman
May	1	Centenary of birth of S. Ramon y Cajal
May	2	Sesquicentenary of birth of H. G. Magnus
May	2	Centenary of birth of F. A. Gooch
July	2	Centenary of death of Thomas Thomson
Aug.	1	Centenary of birth of E. E. G. Wiedemann
Aug.	4	Centenary of birth of (Sir) J. J. Dobbie
Aug.	7	Sesquicentenary of birth of G. H. Hess
Aug.	11	Centenary of birth of H. B. Dixon
Aug.	15	Centenary of death of J. Gadolin
Aug.	30	Centenary of birth of J. H. van't Hoff

Sept.	9	Centenary of birth of J. H. Poynting
Sept.	18	Bicentenary of birth of A. M. Legendre
Sept.	28	Centenary of birth of Henri Moissan
Sept.	30	Sesquicentenary of birth of A. J. Balard
Oct.	2	Centenary of birth of (Sir) William Ramsay
Oct.	9	Centenary of birth of Emil Fischer
Nov.	19	Centenary of birth of C. T. Kingzett
Nov.	20	Sesquitercentenary of birth of O. von Guericke
Nov.	28	Centenary of birth of O. P. Fischer
Dec.	15	Centenary of birth of A. H. Becquerel
Dec.	19	Centenary of birth of A. A. Michelson

ANSCHÜTZ, RICHARD

Born March 10, 1852, at Darmstadt, Germany; died Jan. 8, 1937, at Darmstadt, Germany, age 85.

This German organic chemist, universally recognized as one of the most distinguished of the later 19th and earlier 20th centuries, represents another instance of long and active devotion to research and teaching primarily at a single university. His formal professional training began (1870) at the Darmstadt Polytechnic, continued (1872-74) at the University of Heidelberg under Robert Wilhelm Bunsen (1811-1899), Gustav Robert Kirchhoff (1824-1887), and Hermann Kopp (1817-1892), and culminated (1874) in the usual doctorate. Following a subsequent (1874-75) year at the University of Tübingen under Rudolf Fittig (1835-1910), Anschütz associated himself with the University of Bonn where in various capacities he served (1875-1922) for 53 years. He first served as assistant to Friedrich Auguste Kekulé (1829-1896), with whom he was closely associated for more than two decades and whose biographer he ultimately (1929) became. Upon the departure (1882) of Ludwig Claisen (1851-1930) for England, Anschütz took over the instructional post thus relinquished and began independently to receive doctoral candidates eventually numbering more than 100. He soon (1889) received the title of extraordinary professor and upon the death (1896) of Kekulé became acting director of the Bonn Chemical Institute. Two years later (1898) Anschütz officially succeeded both to Kekulé's chair and to the directorship of the Institute. During his subsequent 24-year tenure of these posts until his retirement (1922), Anschütz not only maintained and extended the research productivity of the group but planned and supervised the construction of a magnificent new laboratory. [For a substantial

account of this enterprise see Chem. Ztg. *26,* 1025-1029 (1902); more details together with a large photograph of the building may be found in a 71-page quarto volume (1904) by R. Anschütz and R. Schulze (the architect) entitled "Das Chemische Institut der Universitat Bonn"].

No detailed account can be undertaken here of the prodigious experimental contributions of Anschütz to the progress of organic chemistry. Present-day students of this field will be cognizant of the frequency with which his name occurs in their literature searches. Most of the 219 titles comprising his bibliography were published in the *Berichte* or in Liebig's *Annalen.* In addition to the inevitable miscellaneous topics, however, his work may be recognized as mainly concerned with studies on polybasic and hydroxy acids (particularly the maleic-fumaric acid system and its homologs), oxalic acid and its derivatives, higher aromatic hydrocarbons, the behavior of phosphorus chlorides on phenols, phenolic acids, and phenolsulfonic acids, the investigation of salicylides and sulfonylides, the structure of the dyestuff Tartrazine, and the chemistry of "tetronic acid" (3-keto-γ-butyrolactone) [Beil. XVII-403] and "benzotetronic acid" (4-hydroxycoumarin) [Beil. XVII-488].

Anschütz was first [Ber. *25,* 3506-3513 (1892); Ann. *273,* 73-96 (1893)] to obtain in tetrasalicylide and polysalicylide [Beil. X-62] polymers of the non-existent salicylic acid lactone. The tetramer crystallized from chloroform as an addition product of composition $(C_7H_4O_2)_4 \cdot 2\ CHCl_3$ which upon heating gave off its solvent of crystallization furnishing chloroform characterized by exceptional purity and stability and therefore well suited to pharmaceutical and medical employment. Anschütz very early recognized the special value to organic chemists of vacuum distillation and published (1887) a 32 page brochure entitled "Destillation unter vermindertem Druck im Laboratorium" which greatly hastened the general adoption of a practical method now regarded both as routine and indispensable. His name is also still associated with those short-range instruments having glass enclosed scales and universally designated as "Anschütz thermometers".

In addition to the activities associated with the direction of original experimental research, Anschütz also carried out two different types of literary enterprise. Over a period of forty years he collaborated in numerous revisions of the textbook of organic chemistry originated by Victor von Richter (1841-1891). The first volume of Anschütz's revision appeared (1894) as Richter's

7th edition; the second volume of its 12th edition was published (1935) when Anschütz was 83 years old.

Anschütz was a great lover of nature, made many journeys to the Alps, and was particularly interested in vulcanology. At the time (1906) of the great eruption of Mount Vesuvius he made a quick and uninterrupted trip to Naples to observe this unusual phenomenon at first hand. He married a daughter of the famed Bonn physiologist Edward Pflüger (1829-1910) and their elder son Ludwig Anschütz (1899-   ) became (1930) professor of organic chemistry at the German Technische Hochschule of Brunn. Richard Anschütz himself was one of the oldest members of the German Chemical Society and served (1918-20) as one of its vice presidents. In later life he was honored (1935) by election as a foreign honorary member of the Royal Society of Edinburgh.

P_1B Ber. *74-A,* 29-74 (1941) (incl. bibliog.): P_3B Z. angew. Chem. *45,* 201-203 (1932): B Ber. *65-A,* 78-79 (1932); *70-A,* 65-66 (1937): B Proc. Roy. Soc. Edinburgh *57,* 400-401 (1936-37).

BALARD, ANTOINE JEROME

Born Sept. 30, 1802, at Montpellier in the Department Herault, Southern France; died April 3 (?), 1876, at Paris, France, age 74.

This French inorganic chemist and pharmacist is best known as the discoverer of bromine. After earlier education at the College of Montpellier, he became (1819) at age 17 *préparateur* at the École de Pharmacie whose diploma he subsequently (1826) obtained. After an appointment (1833) as professor of physics in the Montpellier School of Pharmacy and professor of chemistry in the Faculty of Science, he eventually (1842) succeeded L. J. Thenard (1777-1857) at the Sorbonne. He was elected (1844) to the French Academy of Sciences and was appointed (1846) superintendent of lectures at the École Normale Supérieure, a post which later led to his appointment as inspector-general of higher education. The last two decades of his professional career were spent at the Collège de France in Paris where (1851-76) he succeeded T. J. Pelouze (1807-1867) in the chair of general chemistry.

Balard's discovery of bromine was made at the age of 24 while he was still an obscure assistant at Montpellier. Interested in a study of saline brines from the local marshes, Balard

found that after suitable treatment with chlorine a heavy dark red oil could be separated by distillation or by other extraction. Eventually, after extensive studies of its properties, convinced of the elementary character of his new material, Balard named it bromine (from the Greek for "stench") and published [Ann. chim. phys. (2) *32,* 337-384 (1826); cf. Chem. News *99,* 205-206 (1909)] a full account of his discoveries. The importance of his work was promptly recognized by the Royal Society of London in the award (1830) to him of a Royal Medal although it never elected him to actual membership.

By one of those not infrequent coincidences of science, bromine was also almost simultaneously but quite independently discovered by Karl Jacob Löwig (1803-1890). Upon entering the University of Heidelberg to study under Leopold Gmelin (1778-1853), the 22-year-old Löwig brought from his home at Kreuznach, Germany, samples of a dark red liquid which he had obtained from certain natural brines by chlorination. Before further investigation could be completed, however, the publication of Balard's results gave priority of discovery to the French chemist.

In addition to the discovery of bromine, Balard discovered hypochlorous acid, worked out the constitution of Javelle water, was the first to regard bleaching powder as a double compound of calcium chloride and hypochlorite. He devised (1840) a method for the extraction of potassium salts from sea water but the economic significance of this work was soon afterward neutralized by the discovery of the great Stassfurt deposits.

P_2B J. Chem. Education *3,* 382-384 (1926); *9,* 1925-1928 (1932); *15,* 255 (1938): B J. Chem. Soc. *31,* 512-514 (1877): B Nature *13,* 475 (1876): B J. pharm. chim. (8) *4,* 563-565 (1926): B J. Am. Pharm. Assoc. *23,* 1024-1026 (1934).

Becquerel, (Antoine) Henri

Born Dec. 15, 1852, in Paris, France; died Aug. 25, 1908, at Le Croissic, France, age 56.

This French physicist represented the third generation of a remarkable family from which four members have made distinguished contributions to science. The earliest of this quartet, Antoine César Becquerel (1788-1878), was a pioneer of electrochemistry. The second, (Alexandre) Edmond Becquerel (1820-1891), is known chiefly for his researches on phosphorescence.

The third, (Antoine) Henri Becquerel (1852-1908), is the principal subject of the present digest. The group is currently completed by the latter's son, Jean Antoine Edward Marie Becquerel (1878-). All were physicists, all made important discoveries and inventions, all were for long periods connected with the Paris Muséum d'Histoire Naturelle.

Henri Becquerel received his early education at the Lycée Louis le Grand. At the age of 20 he entered (1872) l'École Polytechnique but two years later (1874) continued his studies at l'École des Ponts et Chaussees, of which afterward he was for a decade the chief engineer. Subsequently, he was appointed (1878) assistant at the Paris Museum of Natural History under his father, Edmond Becquerel, and eventually succeeded (1892) to its Professorship of Physics, a chair already rendered illustrious by his father and grandfather, and earlier by Gay-Lussac (1778-1850) [for a brief account of this laboratory at this time see Nature *71,* 177-178 (1904)]. He also succeeded (1895) his father in the chair of physics at l'École Polytechnique.

Although with his father (Edmond), Henri Becquerel published (1879-83) a series of memoirs on the temperature of the earth, most of the scientific contributions of his earlier period were concerned primarily with light. He was first to observe rotatory magnetic polarization in gases and discovered the magnetic rotation of the plane of polarized light by the earth's magnetic field. He conducted experiments (1886-90) on the absorption of light by crystals, including the anomalies along different axes, and utilized this work in what amounted to a new method of spectrum analysis. He extended his father's studies of phosphorescence, and discovered the laws relating the exciting radiation to the emitted phosphorescence as well as that expressing the diminution of the latter with time. The work for which he is most famous, however, was his discovery (1896) that uranium and its compounds emit invisible but penetrating radiations which can affect photographic plates and produce electrical conductivity in gases. His earliest observations, announced at a meeting of the French Academy of Sciences on Feb. 24, 1896 [Compt. rend. *122,* 420-421 (1896)], represent the first recognition of what was later named radioactivity by Madam Curie. Indeed, it was at the suggestion of Becquerel that Marie Curie undertook for her immortal doctoral thesis (1903) at the University of Paris the study of the radiations produced by a large number of minerals and was thus, with her husband, led through the results obtained from pitchblende to the discovery

of polonium and radium. Although the radiations whose effects were first discovered by Becquerel are collectively designated in his honor as Becquerel rays, they are now known from the work of Sir Ernest (Lord) Rutherford (1871-1937) and others to comprise three different kinds, viz. α-rays consisting of helium atoms each bearing two positive charges; β-rays consisting of streams of negatively charged electrons; and γ-rays, identical with x-rays. [For an important résumé of the history of the discovery of Becquerel rays see Naturwissenschaften *36,* 129-132 (1949); for Becquerel's own account (in French) see Proc. Roy. Institution Gt. Brit. *17,* 85-94 (1902-04].

Henri Becquerel's genius was recognized by many honors. He was elected (1889) to the French Academy of Sciences at the age of 37, and later (1908) became its President. A few months later he was named its Perpetual Secretary but served only six weeks as such. It is curious that three scientists honored by election to this post all died in the year of their appointments, viz. the chemist P. E. M. Berthelot (1827-1907), the geologist A. A. C. deLapparent (1838-1908), and the physicist Henri Becquerel (1852-1908). He served (1897) as president of the Société Français de Physique and was elected an honorary foreign member of the Royal Society of London (1908), a foreign associate of the U. S. National Academy of Sciences, and the Royal Institution of Great Britain (1899). Other honors include that of the Rumford Medal (1900) of the Royal Society, the Barnard Medal (1905) of the U. S. National Academy of Sciences, the Helmholtz Medal (1901), and the joint award (1903) together with Pierre Curie (1859-1906) and Marie Curie (1867-1934) of the Nobel Prize in Physics.

P_1B J. Chem. Soc. *101,* 2005-2042 (1912) (Memorial Lecture) [also reprinted in Vol. II, pp. 217-254 (1914) of Memorial Lectures delivered before the Chemical Society (1901-1913), published by Gurney and Jackson, London, 1914]: P_1B Proc. Roy. Soc. (London) *83-A,* xx-xxiii (1909): B Nature *78,* 414-416 (1908): P_1B Smithsonian Institution, Ann. Rept. for 1908, 769-785 (1909) [translated from Rev. gen. sci. pur. appl. *19,* 802-813 (1908)]: B Naturwissenschaften *36,* 129-132 (1949): B Compt. rend. *147,* 443-451 (1908): B Bull. muséum natl. his. nat. (Paris) *11,* 206-226 (1939); *21,* 648-662 (1949): B Ber. *41,* 3277-3288 (1908): B Jahrb. Radioakt. Elektroniks *5,* 391-394 (1908).

BOUSSINGAULT, JEAN BAPTISTE (Joseph Dieudonné)

Born Feb. 2, 1802, in Paris, France; died May 11, 1887, in Paris, age 85.

Of this French scientist, famous not merely as chemist, physicist, mining engineer, but particularly as agronomist, deplorably little information is available. His scientific education was obtained at the School of Mines of St. Étienne, from which at the age of 19 he published [Ann. chim. phys. (2) *16,* 5-16 (1821)] a memoir on the chemistry of silicides of platinum. Shortly thereafter he was appointed by the Spanish government to a professorship at the mining school of Bogotá, Colombia, South America, in which country he remained for a decade. Upon the outbreak of the revolt which ultimately deprived Spain of all her South American domains, Boussingault joined the rebels and became attached to the staff of the famous Símon Bolívar (1783-1830). After the cessation of hostilities, Boussingault engaged in technical mining work and traveled extensively in the region. It was during this period that having noted [Ann. chim. phys. (2) *30,* 91-96 (1825); *48,* 41-69 (1831)] the prevalence of goiter in some native communities as contrasted with its rareness in others, he analyzed the salt used by the two groups, concluded that lack of iodine was responsible for goiter, and thus was led (1833) to recommend [Ann. chim. phys. (2) *54,* 163-178 (1833)] the use of "iodized" salt. At this time also he made the acquaintance of Alexander von Humboldt (1769-1859), who warmly praised Boussingault's chemical, meteorological, geographical, and astronomical accomplishments.

Upon his return to France, Boussingault served briefly as professor of chemistry at the University of Lyons, but soon accepted the chair of agriculture at the Conservatoire des Arts et Métiers (School of Arts and Trades) in Paris, a position which he held for 48 years (1839-87) until his death. In the same year (1839), he was elected to the Institute of France, i.e., to the French Academy of Sciences, of which save for M. E. Chevreul (1786-1889) he was doyen. He served for three years (1848-51) as a member of the French National Assembly, but as a result of his political opinions was dismissed (1851) from his post at the Conservatoire; this summary action was, however, so vigorously protested by Boussingault's professional colleagues as to compel his reinstatement by the Government. Although he never became a member of the Royal Society of London, he was honored (1878) by its highest distinction, the Copley Medal, bestowed in recognition of his varied contributions to science,

particularly those connected with the development of agriculture. A monument to his memory was erected (1895) in the courtyard of the Conservatoire [for photograph see J. Chem. Education *11,* 216 (1934)]. A portrait of Boussingault is included in H. M. Smith's "Torchbearers of Chemistry", Academic Press, N. Y., 1949, page 36.

Soon after Boussingault's return from South America he married the sister of a former fellow student at St. Étienne and became joint proprietor with his brother-in-law, the father of J. A. LeBel (1847-1930) of subsequent stereochemical fame, of the estate of Pechelbronn in Alsace-Lorraine. Here he established a laboratory, which carried out a long series of important agricultural chemical researches, and has been recognized as constituting the first agricultural experiment station in the modern sense. Among the topics developed by Boussingault were studies of the principles underlying the merits of proper rotation of crops, investigations of the nutritional values of various diets for herbivorous animals, determination of utilization of various constituents of animal fodders, etc. Boussingault showed that plants do not absorb nitrogen from the air but that their content of this element may be completely accounted for in the corresponding fertilizers. As early as 1843 Boussingault published his "Économie Rurale" which, translated and republished (1845) in England under the title "Rural Economy in its Relation with Chemistry, Physics, and Meteorology," was characterized as the most valuable contribution of the century to agricultural chemistry. Much later (1860-74) he assembled most of the results of his researches in the monumental seven-volume "Agronomie, Chimie agricole et Physiologie", of which a second edition (1884) was later required.

B J. Chem. Soc. *53,* 509-513 (1888): B Nature *19,* 39-40 (1879); 36, 134-135 (1887): B Chem. News *55,* 243 (1887): B Pop. Sci. Monthly *33,* 836-841 (1888): B Compt. rend. *104,* 1339-1345 (1887).

Demarcay, Eugene Anatole

Born Jan. 1, 1852, at Paris, France; died 1904, at Paris, France, age 52.

Although this French chemist was the discoverer of one of our rarest elements, little record has been made of his career. It is known that after early education at the Lycée Condorcet and a year in England he entered (1870) the École Polytechnique.

Here he became the pupil of A. A. T. Cahours (1813-1891) to whom he was also for six years (1874-80) an assistant, meanwhile also gaining the friendship of other French savants including C. A. Wurtz (1817-1844), H. St. Clair-Deville (1818-1881), J. B. A. Dumas (1800-1884), Charles Friedel (1832-1899), A. M. Cornu (1841-1902), Paul Schutzenberger (1829-1897), and Lecoq de Boisbaudran (1838-1912). Upon leaving the École Polytechnique he made an extensive trip through Algeria, Egypt, and India, returned to Paris, and devoted the remaining two decades of his life to research in pure sciences.

His earlier papers were almost exclusively concerned with organic chemistry. His study of the essence of Roman camomile, one of the earliest attempts to recognize the components of complex natural oils, led to his isolation of hemiterpenes and esters of unsaturated acids eventually of value to the perfume industry. With Cahours he studied the esterification of primary, secondary and tertiary alcohols with oxalic acid, various organometallic compounds of tin, and independently made pioneer investigations of ethyl acetoacetate and its utility in organic synthesis.

After leaving Cahours' laboratory, however, all of his independent research was confined to inorganic chemistry. At the age of 28 during some experiments on the sulfides of nitrogen, the explosion of an iron pressure vessel cost Demarcay the sight of one eye but despite this handicap he eventually became a noted spectroscopist. It was said that he would read a complex spectrum "like an open book" and was in fact the first to observe the new lines of radium in samples brought by Pierre Curie for his examination. At his laboratory in Paris on the Boulevard Berthier, Demarcay assembled high-vacuum apparatus with which he carried out studies on the volatility of metals such as zinc, cadmium, and gold at very low temperatures and pressures. From about 1885 he devoted himself to studies of the rare earths and became a recognized master of methods for effecting their separation. He exhibited (1900) a remarkable collection of pure crystalline salts of neodymium, praseodymium, and samarium and in the following year (1901) discovered europium.

P_2B Bull. soc. chim. (3) *31,* No. 4, i-viii (1904) (incl. bibliog.): B Chem. News *89,* 137-139 (1904) (English translation of preceding reference but lacks bibliog.): P_3B J. Chem. Education *9,* 1767-1769 (1932).

Dixon, Harold Baily

Born Aug. 11, 1852, at London, England; died Sept. 18, 1930, at Manchester, England, age 78.

This British authority on flame and explosion was the second son of William H. Dixon (1821-1879), traveller and historical writer. After early education (1867-71) at Westminster School, London, he entered Christ Church, Oxford, where his student career (1871-75) was diverted from the classics to science by A. Vernon Harcourt (1834-1919). He was elected to fellowships at Trinity College and at Balliol and taught at both until 1886. He then succeeded Sir Henry Roscoe (1833-1915) in the chair of chemistry at Owens College, Manchester, which for 35 years (1887-1922) he occupied with great distinction. Even after relinquishing to Arthur Lapworth (1872-1941) his teaching responsibilities and becoming professor emeritus, he actively continued research to the end of his life.

Dixon undertook research on gaseous explosions at the instigation of Harcourt, with whom he worked until 1879 in the crypt of one of the monastic buildings on the site of which Christ Church was built and later in the cellar of Balliol which had been used by Benjamin Brodie for his researches on ozone. Of the three periods into which Dixon's researches divide, the first was marked by his discovery (1880) that prolonged drying of a carbon monoxide-oxygen mixture over phosphoric anhydride rendered it nonexplosive to sparks able to ignite an undried mixture. The results of this early Oxford period (1876-81) not only confirmed the validity of Berthollet's "law of mass action" (1805) in gaseous explosions (a conclusion simultaneously and independently established at Heidelberg by Horstman), but also led to the remarkable discoveries regarding the incombustibility of rigorously purified and dried gases by H. B. Baker (1862-1935) who assisted Dixon (1883-85).

In 1880 a disastrous explosion in a 36-inch gas main in Percy and Charlotte Streets and Fitzroy Square near Tottenham Court Road, London, provided dramatic evidence that gaseous explosions travel at higher rates than previously supposed, and Dixon began a systematic investigation of the rate of propagation of gaseous explosions generally. At this juncture M. P. E. Berthelot (1827-1907) and P. Vieille (1854-1934) announced their discovery of the high constant flame speeds attained on detonation. During the next 20 years Dixon so successfully developed the methods initiated by the French that he became the leading authority in this field. In 1893 he gave the Bakerian lecture

[Phil. Trans. Roy. Soc. (London) *A-184,* 97-188 (1894)] on "The Rates of Explosion in Gases" and nine years later published [Phil. Trans. Roy. Soc. (London) *A-200,* 315-352 (1903)] a brilliant memoir embodying his photographic researches on "The Movements of Flame in the Explosion of Gases".

Dixon's third research period (1903-30) was concerned with the ignition temperatures of explosive gaseous media which he was the first to determine with any real accuracy. Late in the period he found that these temperatures are affected by the presence of small amounts of other substances and that iodine vapor markedly raises ignition temperature. It was upon these experiments that Dixon was engaged only a few hours before his death.

Dixon was fond of outdoor sports and played cricket and tennis well into middle life, but his chief physical recreation was mountaineering. In one three-year period (1890-93) he made more than 20 first-class Alpine climbs and later (1897) climbed in the Selkirks, British Columbia, Canada, making first ascents of both Pollux and the Dome and the second ascent of Castor. In the Canadian Rockies he made, with J. Norman Collie and others, the first ascents of Mounts Lefroy and Gordon.

Dixon was elected (1886) to the Royal Society of London and received (1913) one of its Royal Medals. He served as president of the famous Manchester Literary and Philosophical Society (1907-09) and of the (British) Chemical Society (1909-11).

P_1B J. Chem. Soc. *1931,* 3349-3368; also identically in Proc. Roy. Soc. (London) *A-134,* i-xxvi (1932): B Nature *126,* 511-512, 958 (1930): B Chemistry and Industry *8,* 805-806 (1930): B Mem. Proc. Manchester Lit. and Phil. Soc. *75,* ii-iii (1930-31): B J. Chem. Soc. *1930,* Proc. 88-89.

DOBBIE, SIR JAMES JOHNSTON

Born Aug. 4, 1852, at Glasgow, Scotland; died June 19, 1924, at Fairlie, Ayrshire, Scotland, age 72.

This Scottish chemist did most of his work in Wales and England. Entering the University of Glasgow to pursue architecture, he received M.A. (1875) but since his interest then turned to science and Glasgow then offered no science degree, he undertook further study at the University of Edinburgh. Here he came under the influence of Profs. Blackie, Alexander Crum Brown (1838-1922), and (Sir) Archibald Geikie (1835-1924) and attained B.Sc. (1878) and Sc.D. (1879). Meantime, he

spent two semesters at Leipzig studying chemistry with A. W. H. Kolbe (1818-1884) and G. H. Wiedemann (1826-1899) and mineralogy with Ferdinand Zirkel (1838-1912). While at Glasgow, Dobbie became acquainted (1875) with William Ramsay (1852-1916), then an assistant to John Ferguson (1837-1916), and later (1881) succeeded him in this capacity. He next occupied for 19 years (1884-1903) the chair of chemistry at the newly founded University College of North Wales at Bangor, Caernarvonshire. With some misgivings he then accepted (1903-09) the post of director of the Royal Scottish Museum at Edinburgh, although during this period he managed to maintain the research program initiated at Bangor. His last professional post was in London (1909-20), where he succeeded Sir T. E. Thorpe as principal of the government laboratory and (after 1911) became the first Government Chemist. He served in this difficult position through World War I, finally retiring in 1920.

Dobbie's contributions to science were primarily in the chemistry of alkaloids and in the development of ultraviolet absorption spectra as a tool for the establishment of organic structures. While both men were at Glasgow (1876), Ramsay and Dobbie jointly initiated an investigation of the structure of quinine, quinidine, cinchonine, and cinchonidine, about which little was then known. By alkaline permanganate they degraded these substances to pyridinetricarboxylic acids and thus first established them as pyridine derivatives. This work comprised Dobbie's doctoral thesis at Edinburgh. At Bangor, Dobbie greatly extended his alkaloid studies, isolated corydaline, corybulbine and corytuberine, and established the structure of corydaline.

In collaboration with (Sir) Walter N. Hartley (1846-1913) of Dublin, Dobbie began (1898) to study the relation between structure and ultraviolet absorption spectra of organic compounds and established the great utility of this physical method as a regular procedure. They gave particular attention to the investigation of tautomeric substances such as isatin, carbostyril, cyanuric acid, phloroglucinol and many alkaloids. Some 20 years later Dobbie and Fox extended the work to the absorption spectra of gaseous elements. Other miscellaneous topics studied by Dobbie included the first preparation of *o*-bromochlorobenzene and of diphenylene.

While at Bangor Dobbie recognized the special importance of agricultural education including field experimentation and was instrumental in the founding (1889) of the first agricultural department in connection with a university college. As director of

the Edinburgh Museum, he greatly extended its holdings of Egyptian antiquities, the Noel Paton collection of armor, and its sections of natural history and engineering. He served for 14 years as adviser on research programs to the Carnegie Trust for the universities of Scotland, as a member of the Royal Commission on awards to inventors, and in many other public service capacities.

Dobbie served as president both of the Institute of Chemistry (1915-17) and of the Chemical Society of London (1919-21). He was elected to the Royal Societies of Edinburgh and of London in the same year (1904) and knighted (1915) by the Crown.

P_1B J. Chem. Soc. *125,* 2681-2690 (1924) : P_1B Proc. Roy. Soc. (London) *A-107,* vi-viii (1925) : B Nature *114,* 198-199 (1924) : B Chemistry and Industry *2,* 692-693 (1924) : B Proc. Roy. Soc. Edinburgh *44,* 271-272 (1923-24) : B Chem. Age (London) *10,* 670 (1924).

ÉTARD, ALEXANDER LEON

Born Jan. 5, 1852, at Alençon, Orne, France; died May 1, 1910, at Paris, France, age 58.

This French organic chemist spent his boyhood years with his parents in Chile, South America. At the age of 17 he returned to France and, despite a complete lack of any scientific or technical training, persuaded Edmond Frémy (1814-1894) to allow him to work in his laboratory. Here he devoted himself so assiduously to science that upon obtaining his baccalaureate he was recommended by Frémy to Auguste André Thomas Cahours (1813-1891) as préparateur at the École Polytechnique. Here he not only obtained (1880) his doctorate but occupied various posts for some twenty years (1880-1900). Meanwhile, he also held an appointment (1885) as professor at the École Municipale de Physique et de Chimie industrielle. The last decade of his life (1900-10) was spent at the Pasteur Institute of Paris as director of its laboratory of biological chemistry.

Étard's name is chiefly remembered from the Étard reaction. During his doctoral research with Cahours, Étard discovered [Compt. rend. *84,* 127-129 (1877); Bull. soc. chim. (2) *27,* 249-251 (1877)] the action of chromyl chloride (CrO_2Cl_2) on aromatic hydrocarbons and developed it into the well-known synthesis for aldehydes which still bears his name. While associated with Cahours he also carried out research on deriva-

tives of nicotine which laid the basis for its later synthesis by Ame Pictet (1857-1937). Subsequently (1882-84) he collaborated with Armand Emile Justin Gautier (1837-1920) in studying the ptomaines formed during the putrefaction of albuminoids. He also discovered [Compt. rend. *112,* 945-947 (1891)] the hydrocarbon now known as cyclopentadiene and its spontaneous polymerization to dicyclopentadiene.

P_1B Bull. soc. chim. (4) *9,* No.?, i-xix (1911) (incl. bibliog.)

FISCHER, (HERMANN) EMIL

Born Oct. 9, 1852, at Euskirchen (20 miles from Bonn), Rhenish Prussia, Germany; died July 15, 1919 [cf. Z. angew. Chem. *32,* (Aufsatzteil), 360 (1919)] at Wansee, Berlin, Germany, age 67.

This German organic chemist, possibly in scope and magnitude of his accomplishments the greatest in history, received his early education in Bonn and at age 17 spent two years as an apprentice in his brother-in-law's timber business. His desire to pursue a scientific career, however, led him to become (1871) a pupil of Friedrich Auguste Kekulé (1829-1896) at the University of Bonn. In the following year he transferred to the University of Strassbourg and after two years (1872-74) with Adolf von Baeyer (1835-1917) obtained his doctorate (1874) with a dissertation [Ber. *7,* 1211-1216 (1874)] on fluorescein and orcinolphthalein. When at this juncture von Baeyer succeeded to the chair of Justus von Liebig (1803-1873) at Munich, Emil Fischer accompanied him as assistant and during his subsequent seven year (1875-82) stay, presently (1879-82) succeeded Jacob Volhard (1834-1910) as director of the analytical division. At the age of thirty, Fischer again succeeded Volhard at the University of Erlangen but remained here only three years (1882-85). His next academic post was at the University of Würzburg, where he spent seven years (1885-92) in the chair of chemistry as the successor of Johannes Wislicenus (1835-1902). During this Würzburg period was born the eldest of his three sons, Hermann Otto Laurenz Fischer (1888-), currently (1951) in the U. S. A. at the Department of Biochemistry of the University of California at Berkeley. Upon the death of August Wilhelm von Hofmann (1818-1892), the 40-year-old Emil Fischer succeeded him as professor and director of the Chemical Institute of the University of Berlin, where he spent the remaining 27 years (1892-1919) of his life.

Although Fischer's subsequent professional career was primarily concerned with three major fields, viz. sugars, purines, and the interrelation of amino acids, polypeptides and proteins, several earlier accomplishments require brief mention. Although these were executed during the Munich period before he was thirty years old, their consequences were profound both upon organic chemistry and in attracting attention to the man himself. In the year following his doctorate, he first prepared [Ber. *8,* 589-594 (1875); Ann. *190,* 67-183 (1877)] phenylhydrazine, the substance which in his own hands was ultimately to prove the key to the chemistry of the sugars. While in Munich he also collaborated with his cousin (Philip) Otto Fischer (1852-1932) in establishing (1878) the rosaniline dyes as derivatives of triphenylmethane. His doctoral thesis on certain phthalein dyes together with the discovery of phenylhydrazine and the elucidation of the structure of the rosaniline dyestuffs represented Emil Fischer's only concern with the chemistry of organic compounds of the aromatic series.

The beginning of Emil Fischer's colossal contribution to the chemistry of carbohydrates occurred (1884) ten years after his discovery of phenylhydrazine through his recognition [Ber. *17,* 579-584 (1884)] of the class of phenylosazones formed by reaction of simple carbohydrates with an excess of phenylhydrazine. Although the stages of this reaction were at first obscure, he soon [Ber. *20,* 821-834 (1887)] discovered the phenylhydrazones and clarified their role in the reaction. Whereas the initial sugars themselves were so extremely water soluble that the resulting sirups were virtually impossible to characterize, their phenylosazones and phenylhydrazones could readily be recrystallized and purified and generally were much more suited to chemical and physical study than the corresponding parent carbohydrates. Utilizing this entirely new tool and devising many other new methods and techniques, Fischer synthesized not only many of the natural sugars but also produced numerous individual carbohydrates unknown in nature. By application of the stereochemical views of Jacobus Henricus van't Hoff (1852-1911) and of Joseph Achille LeBel (1847-1930) to the problem of the aldohexoses, he was able (1891) to allocate the appropriate configuration to all sixteen possible optical isomers, twelve of which were either synthesized or configurated or both in his laboratory. When it is recalled that in 1886 only two aldohexoses (glucose and galactose) were recognized, and that nothing was known of the configurations of the four asymmetric

carbon atoms possessed by each aldohexose, the magnitude of Fischer's contribution is at least suggested. [For an account of Fischer's discovery of the configuration of glucose see C. S. Hudson, J. Chem. Education *18,* 353-357 (1941).] His work with the various smaller units of the carbohydrate group was gradually extended to their combinations with each other and with entirely different molecules. He discovered (1893) the first methylglucoside and subsequently synthesized many natural and artificial glucosides and polysaccharides. This work eventually led him to studies of the depsides and tannins, in the course of which Fischer and Karl Freudenberg (1886-) prepared [Ber. *46,* 1116-1138 (1913)] hepta-(tribenzoyl-galloyl)-p-iodophenyl-maltosazone, whose molecular weight (4021) vastly exceeded that of any other synthetic product prepared up to that time.

The second major topic of Emil Fischer's life work was concerned with a group of organic compounds to which he gave (1884) the class designation of "purines". This group includes not only uric acid, caffeine, theobromine, and theophylline but also many other substances of physiological interest. In a long series of researches extending over about two decades (1881-1899), Fischer elucidated the structure and effected (or vastly improved) the synthesis of many members of this family, including the first preparation [Ber. *31,* 2550-2574 (1898)] of the parent purine itself. At various times during his pursuit of this topic he established the structure of adenine as 6-aminopurine, of hypoxanthine as 6-hydroxypurine, of guanine as 2-amino-6-hydroxypurine, of xanthine as 2,6-dihydroxypurine, of theophylline as 1,3-dimethyl-2,6-dihydroxypurine, of theobromine as 3,7-dimethyl-2,6-dihydroxypurine, of caffeine as 1,3,7-trimethyl-2,6-dihydroxypurine, and of uric acid as 2,6,8-trihydroxypurine. Fischer's service did not lie in the discovery of the various purines (for example, uric acid had been discovered (1776) by Carl Wilhelm Scheele (1742-1786) and caffeine first isolated (1820) by Friedlieb Ferdinand Runge (1795-1867)), but rather in his establishment of the important representatives as simple derivatives of one fundamental unit (purine), and in the synthetic preparation of numerous other new members of the same family.

The third great contribution of Emil Fischer to organic chemistry and to biochemistry was his extension and development of knowledge of amino acids, peptides, and proteins. When he began (1899) his work in this area it was known that proteins could by hydrolysis or enzymatic disruption be broken down

to amino acids, and the racemic forms of thirteen such fundamental units had thus been obtained. Furthermore, the synthesis of the racemic forms of eight of these had already been effected; viz. alanine (α-aminopropionic acid) (1850), leucine (α-aminoisocaproic acid) (1855), glycine (α-aminoacetic acid) (1858), valine (α-aminoisovaleric acid) (1880), phenylalanine (1882), tyrosine (α-amino-β-(p-hydroxyphenyl)propionic acid (1882), aspartic acid (α-aminosuccinic acid) (1887), and glutamic acid (α-aminoglutaric acid) (1890). The resolution of amino acids into their optically active stereoisomers, however, had been severely limited by experimental difficulties attributable to their amphoteric nature. By repressing their basic character through various means of acylation, however, and thus facilitating their capacity to form salts with natural optically active alkaloids, Fischer and his collaborators were able to obtain for the first time the antipodal components of twelve amino acids including from the preceding group alanine, leucine, valine, phenylalanine, tyrosine, aspartic acid and glutamic acid and beyond it the cases of α-aminobutyric acid, α-amino-n-caproic acid, serine, isoserine, and proline. These materials thus became the building blocks for his later work on their recombination into polypeptides.

Earlier attempts to recognize the individual amino acid components of proteins had also been seriously impeded by experimental obstacles to the separation of the complex mixtures produced by hydrolysis. Although Theodor Curtius (1857-1928) had recognized (1883) that in consequence of the suppression of their carboxylic acid function through esterification the resultant amino acid esters had the properties of aliphatic amines, it was Emil Fischer who modified, developed, and extended this principle into a powerful new tool for their separation from complex mixtures by distillation of their ethyl esters under reduced pressure. The direct result of this increased knowledge of amino acids and their derivatives was the recognition and determination of the components of a wide variety of natural proteins, including special attention (1907) by Fischer himself to the fibroin produced by silkworms and spiders.

Utilizing the vast experience thus acquired through his work on the properties of amino acids and their isolation from protein hydrolysates, Fischer next made an even more important advance in his synthetic studies of the recombination of amino acid units. The recognition of hippuric acid as *N*-benzoylglycine having given a clue to the mode of linking, and the preparation [Ber.

34, 2868-2877 (1901)] of the first dipeptide (glycyl-glycine) supporting this view, Fischer entered upon that remarkable series of polypeptide syntheses which culminated [Ber. *40,* 1754-1767 (1907)] in the preparation of an octadecapeptide, viz. *l*-leucyl-triglycyl-*l*-leucyl-triglycyl-*l*-leucyl-octaglycyl-glycine, comprising 15 glycine units and 3 *l*-leucine units into a molecule of known structure and molecular weight 1213. Nine years later Emil Fischer's most gifted pupil Emil Abderhalden (1877-1950) similarly synthesized [Ber. *49,* 561-578 (1916)] an even larger (mol. wt. 1326) molecule comprising 19 amino acid units, viz. *l*-leucyl-triglycyl-*l*-leucyl-triglycyl-*l*-leucyl-triglycyl-*l*-leucyl-pentaglycyl-glycine. The technical details of the various synthetic methods cannot appropriately be considered here but comprise some of the most fundamental and generally useful tools of chemical and biochemical practice.

Emil Fischer's career was studded with evidences of the general recognition of his extraordinary powers and magnificent accomplishments. He received (1890) the Davy Medal of the Royal Society of London to which (1899) he was elected as a Foreign Member. He was elected foreign honorary member of the Chemical Society of London (1892) and of the Royal Institution of Great Britain (1904). He received (1902) the Nobel Prize for chemistry "in recognition of his special services in connection with his synthetic experiments in the sugar and purine groups of substances". This was the first Nobel Prize to an organic chemist, the initial issue (1901) having been assigned to Jacobus Henricus van't Hoff (1852-1911). It is perhaps significant of the magnitude of Fischer's work with the sugars that no other Nobel Prize was awarded for work in this field for thirty-five years, i.e. until 1937 in the case of Walter Norman Haworth (1883-1950).

In addition to the biographical material comprised in the periodical literature cited below, attention should be drawn to Fischer's autobiography "Aus Meinem Leben" published posthumously (1922) as a volume of 201 pages and three portraits by the press of J. Springer of Berlin.

P_1B Proc. Roy. Soc. (London) *98,* l-lvii (1921-22): P_1B J. Chem. Soc. *117,* 1157-1201 (1920) (Fischer Memorial Lecture; also reprinted in Chemical Society Memorial Lectures, Vol. 3 (1914-32), pp. 1-45, published by the Chemical Society of London, 1914): P_1B Ber. *54,* Special Number, 1-480 (1921) (often separately bound as a book biography): P_1B Naturwissen-

schaften *7,* 843-882 (1919): B Ber. *52-A,* 125-164 (1919): B Science *50,* 150-154, 346-347 (1919): B Nature *103,* 430-431 (1919): P_3B Chem. Ztg. *43,* 565-569 (1919): B Z. angew. Chem. *36,* 47-49 (1923): B Oesterr. Chem. Ztg. *22,* 173-175, 179-182 (1919): B Z. physiol. Chem. *108,* 1-2 (1919): B J. Soc. Chem. Ind. *41,* 495-496 (R) (1922): P_2B J. Chem. Education *5,* 36-42 (1928); P_1B *ibid., 6,* 1190-1192 (1929).

FISCHER, (PHILIP) OTTO

Born Nov. 28, 1852, at Euskirchen, near Cologne, Germany; died April 4, 1932, at Erlangen, Germany, age 80.

This German organic chemist, born in the same city just 53 days later than his more famous cousin and professional colleague Emil Fischer (1852-1919), is furthermore not to be confused with Hermann Otto Laurenz Fischer (1888-   ), oldest son of Emil Fischer. After early schooling in the gymnasia of Bonn and of Aachen, Otto Fischer studied (1871) in Berlin under A. W. Hofmann (1818-1892), in Bonn (1872-74) under Friedrich Auguste Kekulé (1829-1896), and obtained his doctorate (1874) at the University of Strassbourg under A. von Baeyer (1835-1917) with a dissertation on the synthesis of hydrocarbons by condensation of aldehydes with toluene [Ber. *7,* 1191-1197 (1874)]. After a brief postdoctoral sojourn at Berlin-Charlottenburg (1875) during which he collaborated with Carl T. Liebermann (1842-1914), he rejoined von Baeyer (who meantime had transferred to Munich) and spent there several extremely productive years (1878-84) as privat-dozent and assistant. Most of his life, however, was spent at the University of Erlangen where for forty years (1885-1925) until his retirement he was director of the chemical laboratory. When in 1897 he declined a call to succeed Theodor Curtius (1857-1928) at Kiel, Fischer was promised a new laboratory at Erlangen and this was soon afterward (1899-1900) constructed under his direction. It is of interest that the Erlanger chair had initially been accepted by Emil Fischer; when ill health prevented his actual transfer, however, Otto substituted for him. Upon Emil's recovery he accepted an invitation to Würzburg and Otto remained at Erlangen.

Otto Fischer is perhaps most famous for his part of the collaboration with Emil Fischer which resulted in the recognition of the first synthetic dyestuff, the Mauve or Parafuchsin of William Henry Perkin, Sr. (1838-1907), as a derivative of the

hydrocarbon triphenylmethane. They showed that from the dyestuff by successive application of steps involving reduction, diazotization, and eventual replacement of the amino groups by hydrogen, triphenylmethane could be obtained. Conversely this hydrocarbon upon appropriate trinitration, reduction to the corresponding triamine, and suitable oxidation yielded the dyestuff pararosaniline. As a result of their work the constitution and relationships of this whole class of dyestuffs was firmly established. Otto Fischer was also the first (1877) to synthesize the important dyestuff Malachite Green (English Colour Index No. 657). His method, involving the condensation of benzaldehyde with *N,N*,-dimethylaniline, was soon afterward (1878) extended by Oskar Gustav Doebner (1850-1907), who substituted benzotrichloride for the benzaldehyde. Together with E. Hepp (1851-1917), Otto Fischer made extensive studies on the rearrangement of *N*-nitrosoamines to the corresponding nuclear nitrosated bases, and it is their names which are commemorated in the well-known Fischer-Hepp rearrangement.

B J. Soc. Dyers and Colourists *48,* 233 (1932): B Nature *129,* 822 (1932): B Chem. Ztg. *56,* 325 (1932): B Ber. *65-A,* 78 (1932).

GADOLIN, JOHANN

Born June 5, 1760, at Åbo (also known as Turku), Finland; died August 15, 1852, at Wirmo, Finland, age 92.

This Finnish chemical pioneer and teacher sprang from a family long associated with learning and scholarship. His father Jacob Gadolin (1719-1802), at the time professor of physics at Åbo, then the capital of Finland and the seat of its university, subsequently became its professor of theology and eventually Bishop of Åbo. His maternal grandfather, Johann Brovallius (or sometimes Breval) (1705-1755), had also served at Åbo as professor of physics and likewise rose to the bishopric. After completing the high school of his native city, Johann Gadolin studied at the University under Pehr Adrian Gadd (1727-1797), the first occupant of its chair of chemistry, then spent four years in Sweden at the University of Uppsala under Tobern Olof Bergman (1735-1784), during which time he developed a brief but a close friendship with Carl Wilhelm Scheele (1742-1786), abruptly terminated by the death of the latter. Upon the death (1784) of Bergman, Gadolin was a candidate for the Uppsala

post but, when Bergman's nephew Johann Arvidson Afzelius (1753-1837) was chosen, returned to Åbo as (1785) adjunct in chemistry, succeeding upon Gadd's death to the chair of chemistry which he graced (1797-1822) for 25 years until his retirement. He was succeeded by his most brilliant pupil Pehr Adolf von Bonnsdorf (1791-1839). Although Gadolin continued to conduct research for another five years, his scientific career was terminated (1827) by a great conflagration which practically destroyed Åbo and with it the university laboratories and collections. The university was afterward moved to Helsingfors (Helsinki) and Gadolin's remaining quarter century was passed in retirement in the country.

Gadolin participated actively in the conflict between the phlogiston theory and the new views of Lavoisier (1743-1794). At the time (1785) of joining the staff at Åbo, he adhered to the former, subsequently devised a theory of calcination which became a transitional philosophy, and eventually became not only a Lavoisier convert but published (1798) the first Swedish textbook embracing these views. On the practical side, Gadolin established the composition of Prussian Blue and suggested nearly forty years prior to the general introduction of volumetric methods by Gay-Lussac (1778-1850) a quantitative method for the determination of ferrous iron by titrating with standard ferricyanide.

Gadolin's most important chemical contribution, however, was doubtless his discovery (1794) of a rare earth element occurring as its oxide in a black mineral from Ytterby, Sweden. This mineral, now designated as *Gadolinite,* since has been found to have been a mixture of rare earths, but the principal element was later (1797) isolated by Anders Gustav Ekeberg (1767-1813) and called by him yttrium. Gadolin's name is also preserved in another rare earth element, discovered (1880) by Jean-Charles Galissard de Marignac (1817-1894) and named by Paul-Émile Lecoq de Boisbaudran (1838-1912) *gadolinium.* This is the only element named in honor of an individual man.

In honor of their distinguished countryman, the Society of Finnish Chemists (Suomalaisten Kemistien Seuran) established (1936) the Gadolin Fund for the stimulation and support of chemical research, together with the Gadolin Gold Medal for recognition primarily, but not necessarily exclusively, of the contributions of Finnish chemists. The first awards of this medal were made (1937) to Gustav Kommppa (1867-1949) and Ossian Aschan (1860-1939). [For pictures of both sides of the

medal see Ind. Eng. Chem., News Ed. *16,* 585 (Nov. 10, 1938).] A handsome quarto biography of 389 pages by E. Hjelt (1855-1921) and R. Tigerstedt, entitled "Johan Gadolin: In Memoriam, etc." was published (1910) by S. Hirzel of Leipzig.

B Nature *86,* 48-49 (1911): BP_3 J. Chem. Education *9,* 1751-1752 (1932); *14,* 161-165 (1937): B Z. angew. Chem. *40,* 1431-1434 (1927): B Suomen Kemistilehti (Acta Chem. Fenn.) *6,* 107-112; *9A,* 25-27 (1936); *10A,* 106-109 (1937) (in Finnish).

GOOCH, FRANK AUSTIN

Born May 2, 1852, at Watertown, Massachusetts; died August 12, 1929, at New Haven, Connecticut, age 77.

This American pioneer in analytical chemistry was for three decades (1888-1918) identified with the Kent Chemical Laboratory of Yale University. After early education in Watertown and Cambridge, culminating in an A.B. (1872) from Harvard University, Gooch continued there into graduate study, meanwhile acting as assistant to Josiah P. Cooke (1827-1894). His residence was interrupted (1875-76) by mineralogical and crystallographic studies at the Imperial Museum in Vienna. This work, together with a thesis entitled "A Treatise on Crystallography on the Basis of Miller's System," led (1877) to the coupled Harvard degrees of A.M. and Ph.D. Gooch then again went to Europe with the intention of pursuing thermochemical studies at Copenhagen under Julius Thomsen (1826-1909), but when the latter did not encourage this program Gooch resolved his journey into a series of inspections of numerous European laboratories, which later proved advantageous during his supervision (1886-88) of the planning and construction of the Kent Chemical Laboratory at Yale. He next (1877-79) served at Harvard as private assistant to Wolcott Gibbs (1822-1908), an experience which was determinative in attracting Gooch toward devoting his life to the development of analytical chemistry.

During the next seven years, Gooch was concerned with analytical work in connection with the tenth U. S. Census (1879-81), the Northern Transcontinental Survey (1881-84), and the U. S. Geological Survey (1884-86). One permanently important result of this last connection was his examination of the thermal waters of Yellowstone Park [Bull. U.S. Geol. Survey, No. 47, 84 pp. (1888)]. Following these three connections, Gooch removed to New Haven to become professor of chemistry

and director of the new Kent Chemical Laboratory (1886-1918), a connection which comprised his principal life work. He was elected (1897) to the National Academy.

Gooch's name is most familiar to contemporary chemists through the now world-famous Gooch filter. Developed during his work with Gibbs at Harvard [Proc. Am. Acad. Arts and Sci. *13*, 342-347 (1878); reprinted in Am. Chem. J. *1*, 317-323 (1879-80)], this was originally constructed of platinum and its transformation into the now more familiar porcelain came much later [cf. Z. anal. Chem. *64*, 224-227 (1924); *68*, 412-413 (1926)]. Less familiar are the numerous fundamental contributions which Gooch made to the methods of inorganic analytical chemistry, including the separation of lithium from other alkali metals, the determination of boric acid by distillation with methyl alcohol, his important studies on the necessary conditions for suitable precipitation of phosphates, and his extensive development of iodometric methods for the estimation of a wide variety of elements and radicals.

In addition to his research papers, Gooch was the author of several books, including those on "Inorganic Chemistry" (1905 with C. F. Walker), "Qualitative Analysis" (1906 with P. E. Browning), which passed through five additional revised and enlarged editions during Gooch's life, and "Quantitative Analysis" (1916). Besides these, he edited (1901) for the Yale Bicentennial series a two-volume collection of Kent Chemical Laboratory research papers and compiled (1912) a volume of "Methods of Quantitative Analysis originated or developed in the Kent Laboratory".

P_1B Biog. Memoirs Natl. Acad. Sci. U.S. *15*, 105-135 (1934) (incl. bibliog.): P_3B Ind. Eng. Chem. *15*, 1088-1099 (1923): B Am. J. Sci. (5) *18*, 539-540 (1929): B Proc. Am. Acad. Arts Sci. *70*, 541 (1934-5): B Natl. Cycl. Am. Biog. *12*, 329-330 (1904).

GUERICKE, OTTO VON

Born Nov. 20, 1602, in Magdeburg, Prussian Saxony, Germany; died May 11, 1686, at Hamburg, Germany, age 84.

This German natural philosopher was the inventor of the first vacuum pump and of the first machine for generating electricity by friction. As the descendant of a patrician Magdeburg family, he began (1617) the study of law at age 15, first at the University of Leipzig, then at Helmstedt and Jena; while concluding (1623) his professional preparation at the University

of Leyden, Holland, he also interested himself in mathematics and mechanics. After travelling in France and England, he returned (1625) to Magdeburg and began to be active in civic affairs. He promptly (1627) became a member of the city government, and during the siege of Magdeburg (1631), in the course of the Thirty Years War (1618-48), led the attempts to defend the town. These, however, were unsuccessful; the community was almost completely destroyed and most of its inhabitants butchered. Guericke barely escaped with his life and for a time served as quartermaster general in the service of Gustavus Adolphus. Because of his training and ability he was eventually placed in charge of the reconstruction of the city, of which (1646) he became burgomeister (mayor). Although during the next fifteen years he was almost continuously occupied with municipal business, he nevertheless found time for scientific experimentation. His later years were clouded by deplorable ingratitude on the part of his fellow citizens, and finally, at the age of 79, driven out (1681) by the plague, Guericke fled to Hamburg, where he died at the home of his son.

Guericke's strong interest in science, possibly stimulated by reports of the discoveries of Galileo Galilei (1564-1642), Evangelista Torricelli (1608-1647), and Blaise Pascal (1623-1662), turned initially to the study of pneumatics and specifically toward attempts to create empty space. After many abortive attempts to pump out water from a filled container, he finally tried omitting the liquid and was promptly successful in removing the air directly. He constructed (1650) several true air-pumps, each comprising a cylinder and piston with appropriate valves and operating under a water seal. Although these instruments were not themselves described by their inventor, an account of one of them was given (with Guericke's consent) by Kaspar Schott in his "Mechanica hydraulico-pneumatica" of 1657. Substantial modifications and improvements were introduced by the English scientists Robert Boyle (1627-1691) and Robert Hooke (1635-1703). Still further refinements were effected (1709) by Francis Hauksbee (the elder) whose mechanism has been preserved in the collection of the Royal Society of London. These pioneer pumps served during the 18th century but were gradually displaced during the 19th, first by oil-filled, later by mercury-filled machines. Early in the 20th century, rotary pumps were introduced, followed by various modern types of vapor condensation devices.

More important than the mere invention of Guericke's air-pump were the experiments which it made possible for him to execute. These he eventually recorded (1663) in an epochal Latin work entitled "Experimenta nova, ut vocant, Magdeburgia de vacuo spatio", subsequently (1672) printed at Amsterdam. A copy of this very rare item is owned by McGill University, Montreal, Canada. The undertaking actually comprised seven books, of which the third and most important was translated (1894) into German and is now generally accessible as No. 59 of the series by Wilhelm Ostwald (1853-1932) entitled "Klassiker der Exacten Wissenschaften". Guericke showed that light but not sound could be transmitted through a vacuum. He determined directly the specific gravity of air by comparing the weights of the same container when evacuated and when filled with air. He recognized the property of every mass of air to expand throughout all available space. He noted the energy with which equalization of pressure took place and inferred that winds were caused by differences in atmospheric pressure. He was impressed by the hard clash (water hammer effect) produced by two masses of water meeting in an evacuated space. Through these and many other experiments Guericke was first to demonstrate that air was a tangible material which at will could be introduced into and removed from any given space.

Guericke's air-pump was dramatized by its employment in his famous demonstrations (1654) of the Magdeburg spheres. Two copper hemispheres about 22 inches in diameter were placed together to form a sphere, the joint being sealed by an oil-impregnated leather ring. After evacuation of the assembled vessel, it was found that the halves strongly resisted separation even under the force of two oppositely directed teams of eight horses each. On the other hand, after readmission of air to the evacuated space the two hemispheres separated spontaneously. Subsequently, this experiment was repeated, using even larger hemispheres and two teams of twelve horses each.

Otto von Guericke also devised (1650) the first electric machine or electrostatic generator. This consisted of a large ball of sulfur mounted on an iron axis so as to be revolved and rubbed by the hand. With this primitive device, he was able to demonstrate in greater detail the phenomenon of electrostatic repulsion first reported (1629) by the Italian Jesuit Nicolaus Cabaeus, and was first to discover induction, conduction, discharge by proximity to flame, and emission of luminous glow.

Soon afterward (1675) Isaac Newton (1643-1727) substituted a glass globe for the ball of sulfur, but practical utilization of the electrical charges developed had to await the development (1745) of the Leyden jar by Peter van Musschenbroeck (1692-1761).

The only detailed biography of von Guericke derived from original sources is that by F. W. Hoffmann (Magdeburg 1874). However, the first of the references cited below, prepared in commemoration of the 250th anniversary of Guericke's death, is especially valuable and includes many pictures.

P_1B Z. tech. Physik. *17,* 209-218; 345-354 (1936): P_1B Physik. Z. *37,* 771-780 (1936) (identical with second section of preceding reference): B Naturwissenschaften *24,* 305-309 (1936): B Radiography *2,* 6-8 (1936): B Chem. Apparatur *23,* 73-76, 89-92 (1936): B Umschau *40,* 367-370 (1936): B Z. Ver. deut. Ing. *80,* 557-562 (1936).

HESS, GERMAIN HENRI

Born Aug. 7, 1802, in Geneva, Switzerland; died Dec. 12, 1850, in St. Petersburgh, Russia, age 48.

Hess, one of the foremost physical chemists of Russia during the early 19th century, became (1832) professor of chemistry and inspector of mining cadet corps, one of the founders (1828) of the Technological Institute of St. Petersburgh, and a member (1834) of the Russian Academy of Science. His textbook, "Fundamentals of Pure Chemistry" (1831), passed through seven editions (last in 1849). With the collaboration of P. G. Sobolevskij, S. J. Nečaev, and M. S. Soloviev, he devised a rational Russian chemical nomenclature still employed. Internationally, he is best known for his work (1836-41) on heats of chemical reactions, compactly assembled (1890) by W. Ostwald as the ninth of his famous series "Classics of the Exact Sciences", and familiar to chemists as Hess' law of constant heat summation.

P_3B J. Chem. Education *11,* 228 (1934); *28,* 581-583 (1951).

VAN'T HOFF, JACOBUS HENRICUS

Born Aug. 30, 1852, at Rotterdam, Holland; died March 1, 1911, at Steglitz, Berlin, Germany, age 59.

Destined to become one of the greatest of all physical chemists, this Dutch scientist, son of a Rotterdam physician, began his

professional training with two years (1869-71) at the Delft Polytechnicum, and continued it with a year (1871-72) at that oldest and most famous center of Dutch education, the University of Leyden. At the age of 20 van't Hoff next spent a year (1872-73) at the University of Bonn, where the influence of the great Fredrich Auguste Kekulé (1829-1896) was soon to have an important bearing upon his own scientific contributions. The following year (1873-74) van't Hoff spent in Paris at the École de Médecine under Charles Adolphe Wurtz (1817-1884), where he first met the fellow student Joseph Achille Le Bel (1847-1930) whose name was afterward to be so closely associated with his own. Van't Hoff's period of preparation for a scientific career was concluded (1873-74) at the Dutch University of Utrecht where, under Gerardus Johannes Mulder (1802-1880), he carried out a research on cyanoacetic and malonic acids and on Dec. 22, 1874, obtained his doctorate.

Despite the recognition which ultimately he was to receive, the 22-year-old Dr. van't Hoff experienced great difficulty in finding the first rung of his academic ladder. After a year of fruitless effort, he obtained (1876) an appointment as privat dozent at the Royal Veterinary School at Utrecht. In the following year (1877), however, when the ancient Amsterdam Athenaeum became the University of Amsterdam, van't Hoff obtained a post as lecturer. After shortly (1878) being designated as professor of chemistry, mineralogy, and geology, van't Hoff remained as such for 18 years (1878-96), declining (1887) a flattering call from the University of Leipzig to the newly created chair of physical chemistry which was eventually filled by Wilhelm Ostwald (1853-1932). At this juncture, however, van't Hoff accepted an appointment to the Prussian Academy of Sciences at Berlin, Germany, where he was provided with ample laboratory facilities, relieved of all administrative responsibilities, and expected only as an honorary professor of the University of Berlin to give one lecture a week. In this post van't Hoff spent the last 15 years (1896-1911) of his life despite the fact that withdrawal of so distinguished a native son aroused considerable criticism in Holland. [For numerous examples of the biting cartoons stimulated by the circumstances of his withdrawal from Holland see their reproductions in Ind. Eng. Chem. *15,* 192-193 (1923).]

Since the major scientific contributions of van't Hoff may be classified into four principal categories—stereochemistry, chemical equilibrium, theory of solutions, and the physical chemistry

of the Stassfurt salt deposits—brief comments upon each of these aspects may be useful in outlining the nature of his interests.

Only a week after his 22nd birthday and several months before obtaining his doctorate, van't Hoff laid a secure foundation for his subsequent reputation by the publication on Sept. 5, 1874, of a small (11 pp.) pamphlet in Dutch, the translation of whose title reads "An attempt to extend to space the present structural chemical formulae, with an observation on the relation between optical activity and the chemical constitution of organic compounds". Here he stated fully all the fundamental premises of modern stereochemical theory, both optical and geometrical. Two months later Joseph Achille LeBel (1874-1930) entirely independently set forth essentially the same ideas in France [Bull. soc. chim. (2) *22,* 337-347 (1874)]. Despite the fortuitous fact that the two authors had the previous year been classmates in Wurtz's Paris laboratory, neither knew of the stereochemical views of the other, and ever since their independent publications their names have been happily and indissolubly associated. Their great contribution to stereochemistry was to define the structural conditions for asymmetry and to deliver the principle as an effective instrument for the service of their fellow workers. In the following year (1875) van't Hoff's initial Dutch pamphlet was enlarged and translated into the 44-page "La chimie dans l'Espace" (2nd ed. 1887, 3rd. ed. 1892) and a corresponding German version with a foreword by Johannes Wislicenus (1835-1902) soon (1877) appeared as "Die Lagerung der Atome im Raume" (2nd ed. 1894, 3rd ed. 1908). Although his contribution to stereochemistry eventually received the full recognition which it deserved, it initially was received with indifference and by some, including A. W. Hermann Kolbe (1818-1884), with open sarcastic opposition [see J. Soc. Chem. Ind. *43,* 1048-1050 (1924)] and it is perhaps indicative of van't Hoff's good judgment that he had not allowed his natural enthusiasm for his project to lead him to offer it for his doctoral dissertation. [For those wishing to survey more fully the details, circumstances, and consequences of the van't Hoff-LeBel concepts, reference is made to an extensive survey by Ernst J. Cohen (1869-1941) published in Dutch [Chem. Weekblad *21,* 482-501 (1924)] and to two reviews in German by Paul Walden (1863-) [Chem. Weekblad *22,* 34-61 (1925); Z. angew. Chem. *38,* 429-439 (1925)]].

After occupying (1878) the chair at Amsterdam, van't Hoff's

attention turned from organic chemistry to the study of reaction velocities and to the conditions affecting chemical equilibrium. Building upon the foundation laid by the Norwegian mathematical physicist Cato Maximillan Guldberg (1836-1902) and his son-in-law the Norwegian chemist Peter Waage (1833-1900), van't Hoff developed, extended, systematized, coordinated and applied both old information and the results of his own new experiments into a powerful new approach. For example, he first classified reactions into unimolecular, bimolecular, etc., according to the number of participating molecules. He devised new methods for determining the order of a reaction. He pioneered the study of chemical kinetics and the application of thermodynamics to chemical equilibria. He introduced the now well-known symbol $\rightleftharpoons$ for reversible reactions and the term "transition point". He deduced the relationship between equilibrium constant and temperature. He recognized the law of mobile equilibrium, a special case of the more general principle developed in the same year (1884) by Henry Louis Le Chatelier (1850-1936). Much of this progress was collected (1884) in his second epochal book entitled "Études de dynamique chimique", subsequently translated (1896) to both English and German.

The third aspect of van't Hoff's great contribution, his extensive studies on solutions, was a direct outgrowth of the second and indeed more or less overlaps it. He was the first to show (1887) that in a solution of a non-electrolyte the resultant depression of the freezing point and raising of the boiling point is proportional to the number of dissolved molecules. He was first to recognize that the osmotic pressure of such a solution varies with concentration and temperature exactly as does the pressure of an ideal gas and first formulated what has since been called the van't Hoff equation. To represent the colligative properties of electrolytes by means of the relation for non-electrolytes, van't Hoff suggested a factor *i*, the necessity for which was soon accounted for in the electrolytic dissociation theory of Svante Arrhenius (1859-1927) [not to be confused with Axel Arrhenius (1757-1824), the discoverer of gadolinite]. He was the first [Z. physik. Chem. *5*, 322-339 (1890)] to conceive of solid solutions and to study their properties.

Although his contributions to stereochemistry, reaction kinetics and equilibrium, and the theory of solutions would more than have sufficed to establish van't Hoff as the chief founder of modern physical chemistry, he added to them after his removal

(1896) from Amsterdam to Berlin, a fourth epochal contribution in his studies of oceanic salt deposits with particular reference to those at Stassfurt, Germany. In this first and still greatest application of physical chemistry to geological problems, he was notably assisted for a decade by Wilhelm Meyerhoffer (1864-1906), a friend and former pupil who had accompanied his chief to the German capital. The results of their joint investigations, initially recorded in 51 separate papers published between 1897-1906 in the Proceedings of the Berlin Academy of Sciences, have been collected into two volumes (1905, 1909) under the title "Zur Bildung der Ozeanischen Salzablagerungen".

In addition to the scientific papers and books recording the results of his own researches, it should be noted that van't Hoff joined with Wilhelm Ostwald (1853-1932) in establishing (1887) the important *Zeitschrift fur physikalischen Chemie,* of which the two scientists were joint editors continuously through the first 75 volumes until van't Hoff's death (1911). It is also noteworthy that the initial volume of this journal included both van't Hoff's first paper on the role of osmotic pressure in solutions [Z. physik. Chem. *1,* 481-508 (1887)] and that of S. Arrhenius on electrolytic dissociation [Z. physik. Chem. *1,* 631-648 (1887)]. In honor of the 25th anniversary of his doctorate, Vol. 31 (1899) of this journal was dedicated to van't Hoff.

Of the honors bestowed upon van't Hoff, only a few may be mentioned here. He was named an honorary member of the chemical societies of London (1888), Germany (1889), and America (1898). He was elected a foreign member of the American Academy of Arts and Sciences (1895), and after receiving jointly with LeBel the Davy Medal (1893) of the Royal Society of London was elected (1897) to foreign membership. After receiving (1901) the first Nobel Prize in Chemistry ("for his services in connection with the discovery of the laws of chemical dynamics and osmotic pressure in solutions"), he was elected a foreign associate of the U. S. National Academy of Sciences (1901) and of the French Academy of Sciences (1905). He visited the United States in 1901 and an informal account of his experiences [Sci. Monthly *7,* 563-568 (1918)] still possesses interest.

In addition to the numerous citations from the periodical literature, attention should be drawn to two book biographies. Both of these were written by van't Hoff's Amsterdam colleague, the skilled chemical historian Ernst J. Cohen (1869-1941) and are published in German. The older and shorter is the 56-page

brochure published (1899) on the occasion of van't Hoff's doctoral jubilee by the Verlag von Wilhelm Engelmann in Leipzig; the later very extensive (688 pp.) biography appeared (1912) under the title "Jacobus Henricus van't Hoff, Sein Leben und Werken" from the Akademische Verlagsgesellschaft of Leipzig.

P_1B J. Chem. Soc. *103,* 1127-1143 (1913) (van't Hoff Memorial Lecture; also reprinted in Chemical Society Memorial Lectures, Vol. II (1901-1913) pp. 255-271, published by The Chemical Society, London, (1914): P_1B Proc. Roy. Soc. (London) *86A,* xxxix-xliii (1911-12): P_1B Ber. *44,* 2217-2252 (1911): P_1B Z. physik. Chem. *76,* 641-642 (1911); P_1B *ibid., 31,* frontispiece, v-xxv (1899); P_1 *ibid., 50,* frontispiece (1904): B Smithsonian Institution Annual Reports for 1913, 767-789 (1914): P_1B Z. Elektrochem. *16,* 857-865 (1910); P *ibid., 17,* 210-211 (1911); B *ibid., 10,* 479-481 (1904): P_1B J. Chem. Education *6,* 826-829 (1929); *ibid., 7,* 2697-2700 (1930); $3P_2$ (informal) *ibid., 11,* 355-359 (1934); P_3B *ibid., 25,* 303 (1948): B Z. angew. Chem. *24,* 1074-1087 (1911): P_3B Chem. Ztg. *35,* 289-290 (1911): P_3B Oesterr. Chem. Ztg. *34,* 54-59 (1931): B Nature *61,* 321-322 (1900); *86,* 84-86 (1911): B Science *11,* 241-246 (1900): B J. chim. phys. *9,* 503-504 (1911): P_2B Pop. Sci. Monthly *79,* 94-97 (1911): P_1B Proc. Am. Phil. Soc. *50,* iii-xii (1911): B J. Soc. Chem. Ind. *30,* 405-406 (1911): B Chem. Weekblad *1,* 511-517 (1904); *8,* 197-198, 228-238; (P_1) 322-329 (1911); ($2P_3$) *21,* 482-501 (1924); ($3P_3$) *31,* 782-788 (1934); (P_3) *37,* 494-498 (1940); *38,* 116-117 (1941); *44,* 474-477 (1948) (all in Dutch).

KINGZETT, CHARLES THOMAS

Born Nov. 19, 1852, at Oxford, England; died July 29, 1935, at West Byfleet, Surrey, England, age 83.

This British chemist, technologist and author studied chemistry at Oxford University at the age of 14 under Sir Benjamin Collins Brodie (1817-1880) and A. G. Vernon Harcourt (1834-1919). His industrial chemical experience began in his association (1870-72) with Walter Weldon (1832-1885) in the study of manufacturing processes for chlorine and the recovery of sulfur from alkali waste, and (1872-77) as chief chemist of Snape's Soda Works in Liverpool. For a short period (1877-79), he operated (with B. H. Paul) a consulting practice in London. An investigation of the antiseptic properties of conifer essential oils and

their oxidation products led to his establishment (1878) of the Sanitas Company, Ltd., of which he was initially chemist and technical manager, later chairman, resigning in 1926.

Kingzett's first paper [Proc. Chem. Soc. *1873,* 456] was on the formation of sodium sulfide by action of hydrogen sulfide on sodium chloride. He was first [J. Chem. Soc. *13,* 405-410 (1875)] to isolate calcium hypochlorite in crystalline form. He first [J. Chem. Soc. *37,* 792-807 (1880)] established the fact that when phosphorus is oxidized by air or oxygen while partially submerged in water not only is ozone produced (as was previously supposed) but also hydrogen peroxide.

Kingzett was a charter member (1877) of the (British) Institute of Chemistry and (1881) of the (British) Society of Chemical Industry. He served (1885-6) as vice president of the Society of Public Analysts. His several books include "The History, Products and Processes of the Alkali Trade" (1877), "Animal Chemistry, or the Relations of Chemistry to Physiology and Pathology", and particularly Kingzett's "Chemical Encyclopedia" (1st ed. 1919, 6th ed. 1940, revised and edited by R. K. Strong).

B J. Chem. Soc. *1935,* 1899-1902: B Analyst *60,* 649 (1935): P_3B J. Soc. Chem. Ind., Special Jubilee No., page 116 (1931).

Legendre, Adrien Marie

Born Sept. 18, 1752, at Toulouse, France; died Jan. 10, 1833, at Paris, France, age 81.

This French mathematician comprised one of the illustrious trio which included also J. L. Lagrange (1736-1813) and P. S. Laplace (1749-1827). Although Legendre was the youngest, all three were contemporaneously at the height of their powers for a period of some four decades (1773-1813). The subject of this digest is not to be confused with Louis Legendre (1752-1797), the French revolutionist, although the latter was born in the same year.

Subsequent to completion of his education at the Collège Mazarin in Paris, A. M. Legendre held for five years (1780-85) a professorship at the École Militaire. During this period he won (1782) at the age of 30 a prize of the Berlin Academy for a memoir on the trajectory of a projectile and another (1783) of the Paris Academy for an analysis of the attraction of planetary spheroids. These early evidences of mathematical genius attracted

such favorable attention that he was elected (1783) to membership in the French Academy of Sciences, succeeding to the chair of d'Alembert (1717-1783). Shortly thereafter (1789) he was also elected a foreign member of the Royal Society of London at the same meeting which conferred similar honors upon the chemist C. L. Berthollet (1748-1822), his fellow mathematician P. S. Laplace (1749-1827), and both P. F. A. Méchain (1744-1804) and J. D. Cassini (1748-1845), with whom Legendre was currently (1787-89) associated in operations for the junctions of the meridians of Paris and London. Legendre was also appointed (1795) professor at the École Normale and served as a member of various governmental commissions. Later (1824) at the age of 72, however, he declined to bow to government dictation of the Academy, was deprived of his pension, and spent the last decade of his life in poverty.

Legendre's "Élements de Géométrie" (1794), in which he rearranged the propositions of Euclid, eventually appeared in many editions, was translated into almost every European language, and is even now regarded as one of the most successful textbooks ever written. His "Théorie des nombres" (1798), which after a second edition (1808) and two supplements (1816, 1825) appeared still later (1830) as a third edition in two volumes, contained Legendre's law of quadratic reciprocity. This principle, which he had first enunciated much earlier (1785), has been characterized both as "the gem of arithmetic" and the most important general mathematical discovery since P. Fermat (1601-1665) in the science of numbers. Legendre's "Exercices de calcul intégral" (1811, 1816, 1817) contained in its third volume elaborate tables of elliptic integrals together with an account of the method by which they were constructed by the author. Although he had invented these functions and had alone pursued the subject for some 40 years, this treatment had scarcely appeared when the independent work of N. H. Abel (1802-1829) in Norway and K. G. J. Jacobi (1804-1851) in Germany revolutionized it completely. Legendre's last great treatise was the "Traité des fonctions elliptiques, etc." (2 volumes, 1825, 1826, 3rd volume 1833).

Legendre formulated (1806) the first satisfactory treatment of the method of least squares and invented spherical harmonic analysis. His name is still associated with the Legendre coefficients (or functions) of the latter and with the Legendre theorem of spherical trigonometry. He was a member of a commission nominated for the introduction of the metric system

in France; [for a detailed account of his participation in the reformation of weights and measures, see Osiris *1,* 314-340 (1936)].

B Proc. Roy. Soc. (London) *3,* 230-232 (1830-7): B Smithsonian Institution, *Ann. Rept. for 1867,* 131-157 (1872).

MAGNUS, HEINRICH GUSTAV

Born May 2, 1802, in Berlin, Germany; died April 4, 1870, at Berlin, Germany, age 68.

This German scientist was almost equally chemist and physicist. In addition to important research contributions, he also demonstrated exceptional talents in the teaching of both disciplines. He came from a wealthy and talented family of which he was the only scientist, although one of his five brothers, Eduard Magnus (1799-1872), became a celebrated historical painter. After five years at the University of Berlin culminated in his doctorate, H. G. Magnus spent a year (1828) at Stockholm under Jöns Jacob Berzelius (1779-1848), followed by another (1829)in Paris with Joseph Louis Gay-Lussac (1778-1850) and Louis Jacques Thenard (1777-1857). He then returned to the University of Berlin, where, after qualifying (1831) as lecturer in technology and physics, he taught with exceptional brilliance for nearly forty years (1831-70). He rose through the ranks of extraordinary professor (1834) and ordinary professor (1845) to be thrice (1847, 1858, 1863) elected dean of the faculty and to serve (1861) as "rector magnificus". Upon his death, his chair at Berlin was taken over by Hermann Ludwig Ferdinand von Helmholtz (1821-1894).

During the early part of his Berlin career, Magnus also lectured on chemistry at the Berlin Gewerbeschule in the absence of Friedrich Wöhler (1800-1882), and on physics (1832-40) at the Gewerbe-Institut. He was a member of the juries of the London Exhibitions of 1851 and 1862 and of the Paris Exhibitions of 1855 and 1867, and represented Prussia at the Frankfort Conference (1865) on weights and measures which led to the adoption of the metric system throughout Germany. He was instrumental in the founding (1867) of the German Chemical Society and served it as a vice president. He was elected (1863) a foreign member of the Royal Society of London.

Magnus' researches extended over a period of 45 years. His first memoir, published [Poggendorf's Ann. Physik *3,* 81-88

(1825); Ann. chim. phys. (2) *30,* 103-109 (1825)] at the age of 23 while he was still a student, comprised the discovery of the preparation of pyrophoric iron, cobalt and nickel by reduction of their oxides in hydrogen. While working with Berzelius, he discovered [Poggendorf's Ann. Physik *14,* 239-242 (1828); Ann. chim. phys. (2) *40,* 110-111 (1829)] the first of the platino-ammonia complexes (now known as ammines), viz., $PtCl_2(NH_3)_2$, still known as "Magnus' green salt". Soon afterward, together with C. F. Ammermuller, Magnus reported [Poggendorf's Ann. Physik (2) *28,* 514-525 (1833); Ann. chim. phys. (2) *53,* 92-105 (1833); (Liebig's) Ann. *11,* 18-24 (1834)] the discovery of periodic acid and studied certain of its salts. Organic chemistry is indebted to Magnus for his discovery [Poggendorf's Ann. Physik *27,* 367-387 (1833); Ann. chim. phys. (2) *52,* 139-160 (1833); (Liebig's) Ann. *6,* 152-173 (1833) of the three closely related compounds ethyl hydrogen sulfate ("sulfovinic acid") [Beil. I-325], aethionic acid (β-sulfoethyl hydrogen sulfate) [Beil. IV-15], and isaethionic acid (β-hydroxyethanesulfonic acid) [Beil. IV-13].

Magnus also published on a wide variety of topics in physics. Among these may be mentioned here studies of the absorption of gases in the blood (1837-45), the thermal expansion of gases (1841-44), vapor pressure of water and of aqueous solutions (1844-54), thermoelectricity (1851), electrolysis (1856), thermal conductivity of gases (1860) and the polarization of heat (infra-red radiation) (1866-68).

An important and detailed account of Magnus' life and work in the form of a memorial lecture by August Wilhelm von Hofmann (1818-1892) to the German Chemical Society on December 14, 1870 [and often erroneously cited as published in Ber. *3,* 993 ff. (1870)] is actually printed with portrait in Hofmann's classic work entitled "Zur Erinnerung an Vorangegangene Freunde", Vol. I, pp. 45-194 (1888).

B Proc. Roy. Soc. (London) *20,* xxvii-xxix (1871-72): B J. Chem. Soc. *24,* (New Series 9), 610-615 (1871): B Nature *1,* 607 (1870); BP_3 *2,* 143-145 (1870): B Chem. News *21,* 201 (1870): B Smithsonian Institution Annual Report for *1870,* 223-230 (1872): B Ber. *3,* 331-333, 984 (1870): B Moniteur scientif. *12,* 657-660 (1870): B Archives Sci. Phys. Nat. *40,* 61-76 (1871): B Berlin Akad. Abhandl. *1871,* 1-17: B Poggendorf's Ann. Physik (5) *19,* 676 (1870).

MICHELSON, ALBERT ABRAHAM

Born Dec. 19, 1852, at Strelno, then in Germany near the Polish border; died May 9, 1931, at Pasadena, California, age 79.

This great American physicist, the son of Jewish parents who emigrated (1854) to the United States while he was still an infant, obtained his early education in the public schools of San Francisco and of Virginia City, Nevada. Pursuant to the father's desire that his son should enter the American navy, young Michelson took at age 17 the examinations for a congressional appointment to the U. S. Naval Academy at Annapolis. When the coveted place was awarded to a competitor who had equalled Michelson's results, however, he secured a personal conference in Washington with President Grant with a view to obtaining one of the ten Presidential appointments-at-large. When these proved to be otherwise committed, Michelson continued to Annapolis in the hope that a vacancy might develop through some appointee's failure in the physical examination. After waiting three days even this possibility faded and he had just started back to Washington for a second interview with President Grant when he was overtaken by a messenger bearing the news that he had been named as an eleventh appointee-at-large. In view of this unconventional circumstance, Michelson always maintained that his career had been made possible by an illegal though Presidential action.

After an undistinguished career (1869-73) at Annapolis, followed by a period of active duty at sea, Michelson returned to the Academy for service (1876-77) as instructor in physics and chemistry and later (1877-79) as professor of physics. At this juncture, he spent a year (1879-80) in the Washington office of the Nautical Almanac, during which he collaborated with its Director, Simon Newcomb (1835-1909). Accompanied by his wife and their two young children, Michelson spent the next several years (1880-83) in Europe, studying successively at Berlin in the laboratory of H. L. F. von Helmholtz (1821-1894), in Heidelberg with G. H. Quincke (1834-1924), and finally in Paris in the laboratories of A. M. Cornu (1841-1902), E. Mascart (1837-1908), and G. Lippmann (1845-1921). Upon returning from Europe, Michelson then entered upon the academic phase of the professional career which was to see his association with three American universities. This began at the Case School of Applied Science in Cleveland, Ohio, where for six years (1883-89) as professor of physics he was associated with Ed-

ward W. Morley (1838-1923) and carried out the famous Michelson-Morley experiment. For a shorter period (1889-92), he held a similar post at Clark University in Worcester, Massachusetts. His principal academic association, however, was with the University of Chicago, of whose department of physics he was the first head (1892-1925). When at the age of 73 he was succeeded by his friend and collaborator Robert A. Millikan (1868-), Michelson served four years (1925-29) in the first of the University's Distinguished Service Professorships. During his last years (1929-31), he held the title of research associate of the Carnegie Institution of Washington and carried on his work at Pasadena, California.

Michelson's entire life work was concerned with light and optics, particularly with reference to increasing the precision of measurements in this field. His first professional paper, published [Am. J. Sci. (3) *15,* 394-395 (1878)] at age 26 while he was still a student at Annapolis, bears the title "On a Method of Measuring the Velocity of Light"; his last, upon which he was at work only two days before his death and published [Astrophys. J. *82,* 26-61 (1935)] posthumously, has the title "Measurement of the Velocity of Light in a Partial Vacuum".

Although the principal theme of his life work for more than half a century was the measurement of the speed of light with ever-increasing precision, many variations and embellishments of this theme also resulted in epochal scientific advances. Before he was 30 he devised that extraordinary and versatile instrument known as the Michelson interferometer, whose further development and application comprised so large a part of his life work. His first use of this instrument for testing the relative velocity of the earth and the ether [Am. J. Sci. (3) *22,* 120-129 (1881); also reprinted in German in Naturwissenschaften *19,* 779-784 (1931)] culminated (1886-87) in the classical Michelson-Morley experiment [Am. J. Sci. (3) *34,* 333-345 (1887); Phil. Mag. (5) *24,* 449-463 (1887)], now recognized as one of the most fundamentally significant contributions to science since it provided the basis for the special (and later the general) Theory of Relativity of Albert Einstein (1879-).

Beginning in the nineties, Michelson devoted special effort to the attainment of very high spectroscopic resolution, particularly by means of ruled gratings. This work led to the development of the echelon spectroscope, the preliminary announcement of which [Am. J. Sci. (4) *5,* 215-217 (1898)] was quickly followed by full descriptions [Astrophys. J. *8,* 37-47 (1898); Proc. Am.

Acad. Arts and Sci. *35,* 111-119 (1899-1900)]. About this same time, in collaboration with Samuel Wesley Stratton (1861-1931) (later head (1901-23) of the U. S. National Bureau of Standards and President (1923-30) of the Massachusetts Institute of Technology), Michelson developed a new harmonic analyzer [Am. J. Sci. (4) *5,* 1-13 (1898); Phil. Mag. (5) *45,* 85-91 (1898)]. By application of interferometric methods, Michelson (in collaboration with H. G. Gale) made the first accurate measurements of the rigidity and viscosity of the earth [Astrophys. J. *50,* 330-345 (1919); J. Geol. *27,* 585-601 (1919)]. Another application of his optical methods to cosmic problems in the determination of the diameter of Betelgeuse as 240,000,000 miles [Astrophys. J. *53,* 249-259 (1921) with brief version in Proc. U. S. Natl. Acad. Sci. *7,* 143-146 (1921)] represented the first approximately accurate determination of the size of a star.

Despite the fact that most of Michelson's scientific career was spent in academic laboratories, his views on research collaboration with students may have some interest to current workers. After his first decade at Chicago, he gave up completely the conventional association with graduate students and relied exclusively on paid assistants. He is reliably quoted as complaining that "graduate students . . . either spoil the problem for me because they haven't the capacity to handle it as I want it handled and yet they make it impossible for me to discharge them and do the problem myself; or else . . . they get good results and at once begin to think the problem is theirs instead of mine, when in fact the knowing of what kind of a problem it is worth while to attack is in general more important than the mere carrying out of the necessary steps". He took no part in general university administrative or educational problems outside the department of physics.

Although Michelson never received any of the conventional academic degrees as the culmination of any specified program of study, his distinguished scientific accomplishments were recognized by 11 honorary degrees and countless other awards. He was elected (1902) as a foreign member of the Royal Society of London and later (1907) received its highest award, the Copley Medal. In that same year (1907), he was awarded the Nobel Prize in Physics, the first American to receive Nobel recognition in any scientific field. Other notable medals received by Michelson include the Elliott Cresson Medal (1912) and the Franklin Medal (1923) of the Franklin Institute of Philadelphia, the Draper Medal (1916) of the U. S. National

Academy of Sciences, the Gold Medal (1923) of the Royal Astronomical Society, and the Duddell Medal (1930) of the Physical Society of London. Recognition in election to distinguished offices in professional societies includes his service as President of the American Physical Society (1901-3), President of the American Association for the Advancement of Science (1910-11), and President (1923-27) of the U. S. National Academy of Sciences to which he had been elected (1888) at the age of 36.

P_1B Biog. Memoirs Natl. Acad. Sci. U. S. *19,* 121-146 (1938) (incl. bibliog.) : P_1B Obit. Notices, Fellows Roy. Soc. (London) *1,* 18-25 (1932) : 2P_1B J. Opt. Soc. Am. *18,* 147-154 (1929) (incl. bibliog.) : P_1B Science *73,* 549-550 (1931) ; reprinted identically in Phys. Rev. (2) *37,* 1377-1379 (1931) : B Science *69,* 481-485 (1929) : P_2 Sci. Monthly *32,* 566 (1931) ; 2P_2 *ibid. 27,* 566-571 (1928) ; P_2 *ibid. 23,* 567 (1926) : B Proc. Am. Acad. Arts and Sci. *71,* 530-532 (1935-36) : P_1B Nature *117,* 1-6 (1926) : B *ibid. 127,* 751-753, 825-826 (1931) : P_1B J. Chem. Education *8,* 2108-2110 (1931) : B Naturwissenschaften *19,* 777-779 (1931) : B Dict. Am. Biography *12,* 593-596 (1933) : B Natl. Cycl. Am. Biog. P_1B Current Vol. *C,* 42-43 (1930) ; P_1B *33,* 511-513 (1947) ; B *12,* 100 (1904).

MOISSAN, (FERDINAND FRÉDERIC) HENRI

Born Sept. 28, 1852, at 5 Rue Montholon, Paris, France; died Feb. 20, 1907, in Paris, France, age 55.

This French master of inorganic chemistry received his early education in the municipal college of Meaux in the Department of Seine-et-Marne. After two years (1870-72) as an apothecary's apprentice in Paris, he spent a year (1872-73) at the Musée d'Histoire Naturelle studying under Edmond Frémy (1814-1894) and attending the courses of H. St. Claire-Deville (1818-1881), J. Henri Debray (1827-1888) (in whose laboratory he later isolated fluorine), and others. He then transferred to the neighboring laboratory of P. P. Dehérain (1830-1902) in the École Pratique des Hautes Études, with which he was associated for six years (1873-79), during which time he obtained various degrees and published as his first paper and only work outside the field of inorganic chemistry a small contribution on the respiration of plants in the dark. After serving a year (1879-80) as instructor at the Agronomic Institute and obtaining his doctorate (1880) from the University of Paris, he be-

came associated with the École Supérieure de Pharmacie, first (1880-83) as senior demonstrator and later after the death of Jules B. Bouis (1822-1886) as Professor of Toxicology, a chair which he retained (1886-99) for 13 years. Although his sole research interest had been confined to the field of inorganic chemistry for two decades, he first delivered formal lectures in that subject at the École de Pharmacie in 1899. Upon the retirement of Louis J. Troost (1825-1911), Moissan succeeded him in the chair of Inorganic Chemistry in the Faculty of Sciences of the University of Paris (the Sorbonne) and held this post (1900-07) during the brief remaining portion of his life. After Moissan's happy marriage at age 30 (1882) his wife's father, who was extremely sympathetic to scientific study, relieved his son-in-law of all financial concerns and enabled him to devote himself exclusively to study and research.

The most notable of Moissan's contributions to science was his isolation (1886) of elementary fluorine and his subsequent extensive study of its properties and behavior. Although the elementary forms of the other halogens had been known for many years (chlorine from 1774, iodine since 1811, and bromine since 1826), and although fluorides had been recognized since 1813, none of the many attempts to obtain the free element itself had been successful. Moissan became interested in this topic in 1884 and after many fruitless approaches was finally successful on June 26, 1886. This was achieved on the demonstration bench of a lecture theatre of a building in the Rue Michelet, Paris, where, since appropriate electric current was available, Charles Friedel (1832-1899) had given Moissan permission to work between lectures. By means of the electrolysis in a platinum apparatus of anhydrous hydrogen fluoride containing dissolved potassium fluoride, the free elementary fluorine was finally obtained. This important result was two days later communicated to the French Academy of Science by Debray and the facts soon confirmed by a committee of that body. Moissan's own report on the isolation of fluorine appeared [Ann. chim. phys. (6) *12,* 472-537 (1887) cf. Nature *37,* 179-182 (1887)] in the following year. Moissan then devoted himself to extensive improvements of his method and apparatus and to protracted studies of the behavior of gaseous fluorine with other elements and compounds [Ann. chim. phys. (6) *24,* 224-288 (1891); cf. Nature *44,* 622-626 (1891)]. Although space forbids any detailed treatment of this program, it resulted eventually in the discovery with Le Beau in 1900 of the now very important

sulfur hexafluoride SF_6 [Compt. rend. *130,* 865-871 (1900); Bull. soc. chim. (3) *27,* 230-240 (1902)], thionyl fluoride SOF_2 [Bull. soc. chim. (3) *27,* 240-246 (1902)], and sulfuryl fluoride SO_2F_2 [Bull. soc. chim. (3) *27,* 246-254 (1902)]. Meantime, during a visit to the Royal Institution in London, Moissan and (later Sir) James Dewar (1842-1923) effected on May 29, 1897, the first liquefaction of elementary fluorine, and Dewar first obtained solid fluorine six years later (1903). Although in no way detracting from the immense accomplishments of Moissan in the isolation and study of elementary fluorine, the fact that Bohuslav Brauner (1855-1935) had shown four years before Moissan's success that elementary fluorine was evolved upon heating certain complex cerium fluorides [J. Chem. Soc. *41,* 68-77 (1882); Ber. *14,* 1944-1946 (1882); Monatsh. *3,* 1-60 (1882)] appears to have been little recognized.

Moissan's second great contribution to science is represented by his development of the electric furnace and its utilization in the extensive study of chemical reactions at very high temperatures. He devised (1892) an electric furnace yielding temperatures as high as 3500°C., by whose use he was able to prepare metallic uranium, vanadium, zirconium, tungsten, molybdenum, manganese, chromium, tantalum, titanium, niobium, and thorium. He prepared many new metallic carbides, borides, and silicides. In the course of this work, he obtained [Compt. rend. *116,* 1222-1224; *117,* 425-428 (1893)] silicon carbide, but meantime a much more practical method for obtaining this important abrasive had independently been discovered, patented [U. S. Pat. 492,767 Feb. 28, 1893] and fully described [J. Franklin Inst. *136,* 194-203, 279-289 (1893)] by Edward Goodrich Acheson (1856-1931), who had named it "Carborundum". Moissan's electric furnace experiments also led him to a method for the artificial preparation of small diamonds [for important review of this matter see Trans. Am. Electrochem. Soc. *12,* 39-63 (1907)] but this discovery, although naturally seized upon by the popular fancy and press, was actually but a minor contribution as compared with his others.

In addition to some three hundred journal papers recording his results, Moissan summarized in two substantial books the principal interests of his professional career. His work on fluorine was collected (1887) in "Le Fluor" and that on the electric furnace (1897) in "Le Four Électrique". He also prepared (1904-06) with collaborators a five-volume treatise on inorganic chemistry, the "Traité de chimie Minérale".

Moissan received (1887) the Prix Lacaze of the French Academy of Sciences, to which he was elected (1891) succeeding A. A. T. Cahours (1813-1891). He was awarded (1896) the Davy Medal of the Royal Society of London, which later (1905) named him to foreign membership. His greatest honor, however, was the Nobel Prize for Chemistry (1906) awarded in recognition of his isolation and investigation of elementary fluorine and for his introduction to the service of science of the Moissan electric furnace. It is perhaps worthy of note that apart from Moissan only two other strictly inorganic chemists have received Nobel recognition, viz., Alfred Werner (1866-1919) and Theodore William Richards (1868-1928), who were so honored in 1913 and 1915 respectively.

Moissan's only son, Louis Moissan, was killed (1915) during World War I. Prior to his military service he had been an assistant at the École de Pharmacie, to whose reputation his father had so greatly added, and bequeathed to this institution 200,000 francs for the establishment of two prizes in memory of his parents, one for chemistry (prix Moissan) and one for pharmacy (prix Lugan).

P_1B J. Chem. Soc. *101,* 477-488 (1912) (Moissan Memorial Lecture, also reprinted in Chemical Society Memorial Lectures, Vol. II (1901-1913), pp. 187-198, published by the Chemical Society, London, (1914): B Proc. Roy. Soc. (London) *80-A,* xxx-xxxvii (1907-08): P_3B Chemistry and Industry *1946,* 306-308: P_1B Bull. soc. chim. (4) *3,* No. 1 (?), i-xxxviii (1908) (incl. bibliog.): P_1B Ber. *40,* 5099-5130 (1907): B Angew. Chem. *50,* 859-865 (1937): P_3B Chem. Ztg. *30,* 1219-1220 (1906); *31,* I, 311-314 (1907): B Chem. News *95,* 104-105 (1907): P_1B J. Chem. Education *6,* 1608-1610 (1929); P_3B *ibid., 9,* 1930-1936 (1932): B Chimie et industrie, Spec. No. 113-127 (1932).

Nichols, William Henry

Born Jan. 9, 1852, at Brooklyn, N. Y.; died Feb. 21, 1930, while on vacation at Honolulu, Hawaii, age 78.

This American captain of industry studied (1865-68) at Brooklyn Polytechnic Institute and under Dr. John W. Draper (1811-1882) (first president of the American Chemical Society) at New York University, receiving the latter's degrees of S.B. (1870) and M.S. (1873). In later life numerous honorary doctorates were awarded him by other American universities.

Even before completing his work at New York University,

he established (1871) at the age of 19 the chemical manufacturing firm of G. H. Nichols and Company, his father's name being used because the son was still legally a minor. By 1890, when the company was producing heavy chemicals and had undertaken the smelting and refining of copper, the firm name was changed to Nichols Chemical Company of New York. Soon the manufacturing aspects of this firm were consolidated with eleven other independent companies to form (1899) the General Chemical Company which under Dr. Nichols as president (1899-1907) and chairman of the board (1907-20) became the largest American producer of heavy chemicals. The metallurgical aspect was made the exclusive concern of the Nichols Chemical Company, which shortly (1905) became the Nichols Copper Company, whose Brooklyn plant developed into one of the world's largest copper refineries.

In 1913 the General Chemical Company joined with the Semet-Solvay Company and the Barrett Manufacturing Company to form the Benzol Products Company, which became (1918) the National Aniline and Chemical Company. On Dec. 30, 1920, Dr. Nichols organized the new Allied Chemical and Dye Corporation, a consolidation of the General Chemical, Solvay Process, Barrett and National Aniline and Chemical Companies, and served (1921-1930) until his death as chairman of the board of this combination, the securities of which were estimated (1929) to be about $750,000,000.

Dr. Nichols was the next to the last surviving member of the 35 chemists who were present at the organization meeting of the American Chemical Society held on April 6, 1876, in the rooms of the New York College of Pharmacy in the New York University Building. As one of the first Americans to recognize the importance of research to industry, he established (1902) a fund for the annual award of a Nichols Medal by the New York Section of the American Chemical Society with the sole restriction that it should be for original work which would stimulate still further research in chemistry. Dr. Nichols served (1904) as president of the (British) Society of Chemical Industry, an honor which, up to his time, had been accorded to only one other American, C. F. Chandler (1899-1900), and which since has come only to four, viz., M. T. Bogert (1912-3), Ira Remsen (1909-10), A. D. Little (1928-9), and W. P. Cohoe (1943-4). He was a delegate to the Seventh International Congress of Applied Chemistry (London, 1909) and president of the Eighth (Washington and New York, 1912).

His many philanthropies include the gift to New York University of its Nichols Chemical Laboratory (dedicated 1927), together with a residuary legacy estimated at $2,000,000.

P_1B J. Am. Chem. Soc. *52* (Proc.) 47-50 (1930): P_3B Ind. Eng. Chem. *15,* 424-425 (1923); *18,* 317-319 (1926); *22,* 394 (1930); *10,* 92 (1918): P_3B J. Soc. Chem. Ind., Special Jubilee No., 72 (July 1931): B J. Ind. Eng. Chem. *13,* 355-357 (1921): P_3B Chem. Markets *26,* 287 (1930): B Science *71,* 528 (1930): P_1B Natl. Cycl. Am. Biog. *24,* 285-286 (1935).

POYNTING, JOHN HENRY

Born Sept. 9, 1852, at Monton, near Manchester, Lancashire, England; died March 30, 1914, at Birmingham, Warwickshire, England, age 62.

This British physicist studied (1867-72) at Owens College, subsequently to become the University of Manchester. Since at that time it had not the authority to grant degrees, Poynting took the examinations of the University of London, receiving (1872) its B.Sc. He then studied (1872-76) at Trinity College of the University of Cambridge, continuing there with great distinction his training in mathematics and physics. His professional career began with two years (1876-78) as demonstrator at Owens College under Prof. Balfour Stewart (1828-1887), during which he began a warm and lifelong friendship with J. J. Thomson (1856-1940), only four years his junior and still a student. Upon election to a fellowship at Trinity College, Cambridge, he spent two further years (1878-80) in beginning his work on the density of the earth. He then (1880) became professor of physics at the newly established Mason College, whose initial faculty of four included also T. W. Bridge (biology), M. J. M. Hill (mathematics), and (later Sir) William Tilden (1842-1926) (chemistry). When Mason College subsequently (1897) became the University of Birmingham, Poynting continued in the chair of physics and thus accomplished most of his life work during 34 years (1880-1914) at the same institution.

Poynting's more important scientific contributions may be mentioned under three headings. The earliest comprised his protracted studies "On a Determination of the Mean Density of the Earth and the Gravitation Constant by Means of the Common Balance" [Phil. Trans. Roy. Soc. (London) *A-182,* 565-656

(1891)], a process popularly known as "weighing the earth". In addition to its specific objectives, this long investigation added much to our knowledge of the techniques of accurate weighing. Late in life Poynting devoted much attention to studies of radiation and the pressure of light. His most important work, however, concerned the flow of electric and magnetic energy and led to the formulation of the so-called Poynting theorem and the Poynting vector. These, comprising one of the most important contributions to electromagnetic theory, were published in two papers entitled "The Transfer of Energy in the Electromagnetic Field" [Phil. Trans. Roy. Soc. (London) *A-175,* Pt. II, 343-361 (1885)] and "Electric Currents and the Electric and Magnetic Induction in the Surrounding Field" [Phil. Trans. Roy. Soc. (London) *A-176,* 277-306 (1886)].

Poynting was elected (1888) to the Royal Society of London, received (1905) its Royal Medal, served (1909-11) on its Council and was a vice president (1910-11). He served (1905-06) as president of the Physical Society of London and was presiding officer of Section A (Physics) of the British Association at its Dover meeting of September 16, 1899, memorable for his friend J. J. Thomson's announcement of his discovery of the separate existence of electrons.

In addition to his numerous research publications (subsequently issued collectively in 1920), Poynting collaborated with J. J. Thomson in the extended Poynting and Thomson "Textbook of Physics", whose several volumes passed through many editions and since the death of both original authors have evolved into the University Textbook of Physics, whose first volume (1947) represented a 14th edition of the original and whose second (1949) comprised a corresponding 10th edition.

P_1B Proc. Roy. Soc. (London) *92,* i-ix (1916) : B Nature *93,* 138-140 (1914) : B Dict. Natl. Biog. *1912-1921,* 441-442 (1927).

RAMON Y CAJAL, SANTIAGO

Born May 1, 1852, at Petilla de Aragon, a little village which through a strange geographical freak is situated in the province of Zaragoza but belongs to that of Navarra, Spain; died Oct. 17, 1934, at Madrid, Spain, age 82.

This Spanish histologist, medical investigator, author and statesman, although little known to scientists outside his own

professional field, has been characterized by some authorities among the greatest biologists of history. His father, himself a doctor's son of peasant stock, passionately desired a medical career for his own child, but attempts to provide an appropriate educational foundation, first at the College of Esculapian Fathers in Jaca and subsequently at the Institute of Huesca, were frustrated by the headstrong resistance of the boy. In desperation, the father apprenticed Santiago first to a barber and afterward to a shoemaker as punishment for his rebellious attitude toward serious study. This extreme measure so far effected the desired discipline, however, that at age 16 the son entered (1868) the University of Zaragoza, in which soon afterward (1870) his father also secured an appointment as professor in the faculty of medicine. Soon after obtaining (1873) his license to practice medicine, the son obtained a commission in the Army Medical Corps and spent a year (1874-75) on service in Cuba. Compelled by ill health to return (1875) to Zaragoza, he joined the University staff as assistant in anatomy, obtained his medical doctorate, and was appointed (1879) Director of the University Museum of Anatomy. His stay of nine years (1875-84) at Zaragoza was followed by brief periods in the chairs of anatomy at Valencia (1884-87) and at Barcelona (1887-92), after which he spent three decades (1892-1922) as professor of histology and pathological anatomy at the University of Madrid. During this tenure he was appointed (1900) director of the newly organized Alfonso XII National Institute of Hygiene, and upon his retirement (1922) the government established a biological research center named in his honor, the Institute Cajal. After a decade of active work in its initial location, this organization was provided (1932) with magnificent new quarters on the hill of San Blas. [For photographs of both old and new buildings, see Sci. Monthly *31,* 180, 181, 182 (1930)].

It is quite beyond the scope of this digest to attempt any detailed survey of Ramon y Cajal's professional contributions. However, it was his work on the fine structure of the nervous system which first established that clear understanding of its functioning that is the basis of modern physiology, psychology, and psychiatry. Early in his professional career he established that the nervous system is composed of conductive chains of individually distinct and discrete nerve cells. Much later the nerve cell was designated by Wilhelm von Waldemeyer (1836-1921) of Berlin as the "neuron", and despite the fact that

he had at no time contributed either to the experimental discoveries or to the consequent generalizations, the neuron theory is often mistakenly attributed to the German anatomist. In the course of his experimental studies, Ramon y Cajal also did pioneer work in the development of selective procedures for the differential staining of nerve tissue.

Throughout his long life Ramon y Cajal was distressed by the relative isolation of Spanish science and made determined efforts, often at personal expense from meager resources, to improve its means of publication. While still at Barcelona he began (1888) the *Revista trimestral de histologia normal y pathólogica* (Trimonthly Review of Normal and Pathological Histology) whose limited edition of sixty copies were distributed to foreign scientists. This was succeeded (1896) by his *Revista trimestral micrográfica* (Trimonthly Micrographical Review). With volume six, this became an annual entitled *Trabajos del laboratoria de investigaciones biológicas* (Works of the Laboratory of Biological Research), published since 1924 in French as the *Travaux du laboratoire de recherches biologique de l'Université de Madrid.*

In addition to these periodicals Ramon y Cajal was the author of several noteworthy scientific books. The earliest of these was his *Manual de histología normal y téchnica micrográfica* (Manual of Normal Histology and Micrographic Technique), comprising 692 pages of small print and 303 woodcuts of his own anatomical preparations, issued in two editions (1889, 1893). His monumental *Textura del sistema nervioso del hombre y de los vertebrados* (Texture of the Nervous System of Man and of the Other Vertebrates), appearing (1899-1904) in two volumes containing 1800 large pages with 897 original illustrations, was revised and amplified in the French edition of 1909-11. This is still regarded as the most complete and accurate description of the more delicate nerve structures ever recorded. This already impressive list of monographs was climaxed (1913-14) by the two large volumes of *Estudios sobre la degeneración y la regeneración del sistema nervioso* (Studies on the Degeneration and the Regeneration of the Nervous System), the publication of which was financed by the physicians of the Argentine Republic and which was issued (1928) in English by the Oxford University Press.

Although his outstanding contributions were but slowly recognized by his contemporaries, honors in abundance were eventually heaped upon Ramon y Cajal. He delivered (1894) the Croonian Lecture of the Royal Society of London. He was

one of five European scientists who participated (1899) in the celebration of the first decade of Clark University at Worcester, Massachusetts, U.S.A. He received (1905) the Helmholtz Medal of the Royal Academy of Sciences of Berlin and in the following year (1906) shared with the Italian Camillo Golgi (1843-1926) the sixth annual Nobel Prize to be awarded in the fields of physiology or medicine. He was elected (1909) a foreign member of the Royal Society of London, the first Spanish scientist so honored in more than 150 years, and named (1920) as foreign associate of the U. S. National Academy of Sciences. After his death the Spanish Government undertook a complete republication of his works and proposed the issuance of a commemorative postage stamp showing him at his microscope. His statue is prominent in the Bueno Retiro Garden of Madrid.

In addition to the limited number of selected references cited at the end of this digest, attention is particularly directed to the unusual circumstance of an extensive and fully illustrated autobiography published in the periodical literature. This is his *Recuerdos de mi vida* (Recollections of My Life), translated by E. Horne Craigie and J. Cano from the third Spanish edition (1923) and published in the Memoirs of the American Philosophical Society *8*, Part I, 1-272; Part II, 275-638 (1937). This treatment includes a complete bibliography accompanied by a full list of his distinctions, prizes, honorary degrees and awards. Furthermore, a book biography (303 pages) of Ramon y Cajal under the title "Explorer of the Human Brain" by Dorothy F. Cannon has been published (1949) by Henry Schuman of New York. Both of these easily accessible biographical treatments are warmly commended to the attention of all persons interested in science.

P_1B Biog. Notices Fellows Roy. Soc. (London) *1,* 425-441 (1932-35): P_2B Sci. Monthly *31,* 178-183 (1930); *39,* 567-570 (1934): B Nature *134,* 871-872 (1934): B Naturwissenschaften *23,* 503-506 (1935).

Ramsay, (Sir) William

Born Oct. 2, 1852, at Queen's Crescent, Glasgow, Scotland; died July 23, 1916, at Hazlemere, near High Wycombe, Buckinghamshire, England, age 63.

This truly illustrious chemist, one of the outstanding experimentalists of his (or any other) time, occupies a unique position

in chemical history as the discoverer of five elements and the first to recognize transmutation of one element to another. He was the nephew of Sir Andrew C. Ramsay (1814-1891), geologist, and for many years head of the Geological Survey of Great Britain. After a classical education in Glasgow Academy, he entered the University of Glasgow at the age of 14 and during his four year (1866-70) course, which included lectures in physics under William Thomson (1824-1907) (afterward known as Lord Kelvin), became attracted to the pursuit of chemistry. His graduate study began with a single semester (1870-71) at Heidelberg under Robert Wilhelm Bunsen (1811-1899), but Ramsay then transferred to the University of Tübingen where under Rudolf Fittig (1835-1910) he obtained (1872) his doctorate. Returning to his native city, Ramsay served two years (1872-74) in the Young Laboratory of Technical Chemistry of Anderson's College, and afterward six years (1874-80) at the University of Glasgow as assistant to Prof. John Ferguson (1837-1916). At the age of 28 Ramsay was appointed professor of chemistry at University College, Bristol, England, where, during most of his seven-year (1880-87) stay, he also served as principal. In 1887 Ramsay succeeded the renowned Alexander W. Williamson (1824-1904) as professor of chemistry at University College, London, where for approximately a quarter century until his retirement in 1913 he carried on his most important work.

Ramsay's professional contributions may be arranged in four principal groups, the earliest of which was primarily concerned with organic chemistry. His doctoral dissertation [Ann. *168,* 242-253 (1873); J. Chem. Soc. *25,* 491 (1872)] demonstrated the structure of the toluic acid of m.p. 104° as the *ortho* isomer. In collaboration with J. J. Dobbie (1852-1924) at the University of Glasgow, Ramsay showed [J. Chem. Soc. *33,* 102-104 (1878); *35,* 189-196 (1879)] that quinine, quinidine, cinchonine, and cinchonidine upon oxidation with permanganate all gave the same pyridine-2,3,4-tricarboxylic acid (α-carbocinchomeronic acid), incidentally demonstrating for the first time the important relation of these alkaloids to pyridine. During this period he also effected [Phil. Mag. (5) *2,* 271 (1876); (5) *4,* 241 (1877)] the first synthesis of pyridine by passing through a hot tube a mixture of hydrogen cyanide and acetylene.

Upon removing from Glasgow to Bristol, however, Ramsay's research interests shifted to physical chemistry. The numerous publications of this period include the studies with his assistant

Sydney Young (1857-1937) of the relations between vapor pressure and temperature, the evaporation and dissociation of liquids, and the critical state. With Young he devised [J. Chem. Soc. *47,* 640-657 (1885)] the method for maintaining constant temperatures by means of the vapors of liquids of appropriate boiling points which has since become commonplace procedure. He made extensive studies of the molecular complexity of pure liquids, verified [J. Chem. Soc. *63,* 1089-1109 (1893); Phil. Trans. Roy. Soc. (London) *184,* 647-673 (1893)] the Eötvös (1848-1919) law of constancy of rate of change of molecular surface energy with temperature and with John Shields (1869-1920) established the well-known Ramsay-Shields equation.

The third category of Ramsay's many achievements comprises his discovery of the rare gases. In 1893 subsequent to the discovery of Robert John Strutt, the Third Lord Rayleigh (1842-1919), that the density of supposedly pure nitrogen obtained from air was slightly greater than that of samples prepared by chemical means, Ramsay responded to the published [Nature *46,* 512-513 (1892)] appeal of Rayleigh for chemical assistance, and received permission to experiment with atmospheric nitrogen. His observations soon led to direct collaboration with Lord Rayleigh and resulted in the announcement (1894) and publication [Proc. Roy. Soc. (London), *57,* 265-287 (1895)] of the discovery of a new element, a chemically inert gas which was named argon. Ramsay's subsequent search for other sources of this then unique element led him to heat samples of the mineral cleveite and to the discovery (1895) of the first terrestrial occurrence of a second inert gas whose lines had long since (1868) been observed in the solar spectrum and which had already been named helium by Sir J. Norman Lockyer (1836-1920). Although the demonstration of the presence of helium in air was to become (1895) the work of Heinrich J. G. Kayser (1853-1940), Ramsay had by this time been led to suspect the existence of still other inert gases. With the collaboration of Morris W. Travers (1872-) he presently obtained (1898) by careful fractionation of some fifteen liters of supposedly pure argon from liquid air, the still rarer inert elements krypton, neon, and finally xenon. [Many fascinating details of the story of the discovery of the rare gases are recorded elsewhere, notably in Ramsay's own book "The Gases of the Atmosphere; the History of their Discovery", Macmillan and Co., London, 1915; in that of M. W. Travers' "The

Discovery of the Rare Gases'', Edward Arnold and Co., London, 1928; and in M. E. Weeks' ''Discovery of the Elements'', 5th edition, pages 469-481, published 1948 by the Journal of Chemical Education.]

The fourth and undoubtedly most important chapter of Ramsay's contributions to science was that associated with his studies of the decomposition of radium. Following the discovery (1898) of this element through the joint work of Pierre Curie (1859-1906) and his wife Marie Skladowska Curie (1867-1934), Ramsay and his collaborator Frederick Soddy (1877-) showed [Proc. Roy. Soc. (London) *72,* 204-207 (1903)] that the spontaneous decomposition of radium gave *both* helium and another new inert gas [the latter having already (1900) been noted by Fredrich Ernst Dorn (1848-1916)] designated by Ramsay as ''niton'' but subsequently named radon. This represented the first definite evidence of the transmutation of one element to another and may thus be regarded as the birth of the science of radiochemistry and the study of atomic energy. During further investigations of this field, Ramsay, together with Robert Whytlaw-Gray (1877-) reported [Proc. Roy. Soc. (London) *84,* 536-550 (1910-11)] one of the most remarkable pieces of experimental work ever accomplished on a micro scale up to that time. By direct weighing of a barely perceptible bubble of radium emanation, amounting only to 0.0658 cubic millimeters (i.e. to 6.58×10^{-5} cubic centimeters) they determined its density, incidentally calculating its atomic weight and determining its boiling point, melting point, critical temperatures and critical pressure.

Ramsay was active in the professional societies of his period and deeply concerned with problems of higher education. He was a charter member of the (British) Society of Chemical Industry and later (1903-04) served as its president. He was one of three British delegates to the famous commission which established (1892) the Geneva nomenclature [for group photograph see J. Chem. Soc. *1938,* facing page 1117]. He later served as president (1907-09) of the Chemical Society of London and (1911) of the British Association. He was appointed (1900) adviser to the government of India on the establishment of a new University from funds bequeathed by Mr. J. N. Tata of Bombay. This activity eventually resulted in the establishment (1906) at Bangalore of the Indian Institute of Science, of which Ramsay's assistant Morris W. Travers served (1906-14) as the first director.

In recognition of his accomplishments Ramsay was showered with many honors and eventually was elected to most of the world's scientific academies and societies. He was elected (1888) to the Royal Society of London, was awarded (1895) its Davy Medal and was to have received (November 1916) its highest award, the Copley Medal. Together with Lord Rayleigh he was awarded (1895) the Hodgkins Prize of $10,000 by the Smithsonian Institution of Washington. He received (1897) the Longstaff Medal of the Chemical Society of London, was knighted (1902) by the British Crown, and received the Nobel Prize in Chemistry in the same year (1904) as that in which his earlier colleague Lord Rayleigh was awarded the corresponding Nobel Prize in Physics.

[In addition to the biographical material contained in the scientific periodical literature cited below, important treatments may be found in several books, including Sir William Tilden's "Life of Sir William Ramsay", Macmillan and Co., London, 1918; Benjamin Harrow's "Eminent Chemists of Our Time", 2nd edition, pp. 41-58, 286-309, D. Van Nostrand Co., Inc., New York, 1927; and by M. W. Travers in "British Chemists", pp. 146-175, The Chemical Society of London, 1947.]

P_1B Proc. Roy. Soc. (London) *93-A,* xlii-liv (1917): B J. Chem. Soc. *111,* 369-376 (1917) reprinted from J. Soc. Chem. Ind. *35,* 877-880 (1916): B J. Franklin Inst. *186,* 29-55 (1918) (incl. bibliog.); *182,* 267-270 (1916): B Nature *88,* 339-342 (1912); *97,* 482-485 (1916); *115,* 47, 121-122 (1925); *135,* 619 (1935): B J. Am. Chem. Soc. *39,* Proceedings 19-24 (1917): B Sci. Monthly *9,* 167-178 (1919): B Bull. soc. chim. (4) *25,* 401-426 (1919) (incl. bibliog.): B Chem. Ztg. *40,* 733-735 (1916): B Z. angew. Chem. *22,* 529-530 (1909): B Analyst *41,* 329-333 (1916): B Proc. Am. Phil. Soc. *56,* iii-viii (1917): P_2B J. Chem. Education *4,* 812 (1927): P_3B J. Soc. Chem. Ind., Spec. Jubilee No., 71 (1931): B Dict. Natl. Biog. *1912-21,* 444-446.

STILLMAN, JOHN MAXSON

Born April 14, 1852, in New York City, N. Y.; died Dec. 14, 1923, at Stanford University, Palo Alto, California, age 71.

This American chemist, educator, administrator and historian of chemistry removed to California at the age of 9 and his early education was obtained in the public schools of San Francisco. He entered (1870) the University of California

which had been opened the previous year and was then located in Oakland. After graduating (Ph.B. 1874) he declined the post of private secretary to ex-Governor Leland Stanford in order to pursue graduate study in chemistry, first at the University of California and later (1875-76) in Germany at the Universities of Strassburg and Würzburg. Upon his return to America he served for six years (1876-82) as instructor in general and organic chemistry at his alma mater which subsequently awarded him the degrees of Ph.D. (1885) and LL.D. (1916). At this juncture, however, Stillman accepted an offer to enter industry as chief chemist and superintendent of the Boston and American Sugar Refining Companies and during his nine-year stay (1882-91) also lectured on sugar technology at the Massachusetts Institute of Technology, then located in Boston.

Dr. Stillman's principal professional career, however, was devoted to Leland Stanford University, with which in various capacities he was connected for the remaining 31 years (1892-1923) of his life. This institution had been founded (1885) by Leland Stanford (1824-1893) and Mrs. Stanford as a memorial to their son, Leland Stanford, Jr., who had died (1884) at the age of fifteen. Its initial endowment of $20,000,000 was more than doubled after the death of the ex-governor and senator so that by 1901 it was the wealthiest educational institution in the world. Soon after it opened its doors to students in the fall of 1891, Dr. Stillman became head of its department of chemistry, a post which he retained (1892-1917) until his retirement. In fact, of the fifteen professors with which the university began its distinguished career, Dr. Stillman was the only one selected by the founder himself. James M. Stillman's father, Dr. J. D. B. Stillman (1819-1888), had been closely associated with the ex-governor, particularly in connection with the application to the latter's interest in the breeding and racing of horses of the methods of instantaneous photography which eventually resulted (1882) in the famous volume, "The Horse in Motion," executed and published under the auspices of Leland Stanford (Sr.). During the process of assembling a new faculty Mr. Stanford recalled that his associate's son had left his teaching career at the University of California to enter industry and arranged to effect his return to the academic field. His work in the organization and development of the University's Department of Chemistry led (1913) to his selection as vice-president of the institution.

Stillman's great services as teacher, administrator and lov-

able human being have been recorded by a memorial volume containing essays by five colleagues, complete bibliography, and portrait [Stanford University Press, 1924]. His earlier chemical work was concerned with a variety of topics, but in later life his interest concentrated upon history of chemistry. Of the papers on this theme [reviewed in J. Chem. Education *6,* 466-472 (1929)] his most original is "Petrus Bonus and supposed chemical forgeries" [Sci. Monthly *17,* 318-325 (1923)]. In addition he published two books, one an important research on the life and work of Paracelsus (1920), the other, "The Story of Early Chemistry" (published posthumously 1924), a landmark among English expositions of the history of chemistry.

[The subject of this brief digest is not to be confused with Thomas Bliss Stillman (1852-1915), American chemist and chemical engineer, for whose history see Dict. Am. Biog. *18,* 27-28 (1936) and Natl. Cycl. Am. Biog. *16,* 191 (1918)].

P_1B Isis *34,* 142-146 (1942) (incl. bibliog.): P_1B J. Chem. Education *6,* 466-472 (1929): P_3B Ind. Eng. Chem. *15,* 1283 (1923): B Science *59,* 270 (1924): P_3B Natl. Cycl. Am. Biog. *20,* 145 (1929).

THOMSON, THOMAS

Born April 12, 1773, at Crieff, Perthshire, Scotland; died July 2, 1852, at Kilmun, Argyleshire, Scotland, age 79.

This Scotch chemist, editor, and pioneer historian of chemistry is not to be confused either with Thomas Thomson (1768-1852), the contemporary British jurist and legal antiquary, or with his own son Thomas Thomson (1817-1878), distinguished botanist and explorer. The subject of this digest, after a classical education at Crieff and Stirling, spent three years (1787-90) at the University of St. Andrews, Scotland. He then (1791) removed to Edinburgh where subsequently (1795-99) he studied medicine and obtained his M.D. (1799) with a dissertation "De Aere Atmospherico". For the next decade (1800-11) he remained at the University of Edinburgh as lecturer in chemistry and during this period opened (1807) a laboratory for the instruction of students which was the first of its kind in Great Britain. Following his election (1811) to the Royal Society of London, the next six years were spent in that city mainly in literary pursuits. At the age of 44 and on the recommendation of Sir Joseph Banks (1743-1820), Thom-

son was appointed (1817) lecturer on chemistry at the University of Glasgow, Scotland, where in the following year (1818) he became its first Regius Professor of Chemistry, a chair which he retained for 34 years (1818-52) until his death and whose next occupant was Thomas Anderson (1819-1874). Owing to a decline of Thomson's health, his nephew Robert Dundas Thomson (1810-1864) assisted his uncle for four years and carried on all his uncle's duties for the last six years (1846-52) of his life.

At the age of 23 Thomson succeeded (1796) his elder brother James as Editor of the Supplement to the Encyclopedia Britannica and the articles which he also contributed to it formed the basis for his later famous "System of Chemistry" (1st ed. 1802, 4 volumes . . . 6th ed. 1820, 4 volumes, also several French, German, and American editions). The third edition (1807) was especially notable in containing the first detailed account of the atomic theory of John Dalton (1766-1844) which had been communicated to him during a visit to Dalton in Manchester in August 1804 and was both fuller than and substantially antedated the account published in 1808 by Dalton himself. The only previous comparable work was the great treatise (1801, 11 vols.) of Antoine-François de Fourcroy (1755-1809) which was, however, inferior to Thomson's in both content and style as well as too closely confined to French discoveries. The "System" was eventually split into separate works on inorganic chemistry (1831), organic chemistry (1838, 1843), mineralogy (1836), and heat and electricity (1830, 2nd ed. 1840). After Thomson's death the "System of Chemistry" was superseded by Leopold Gmelin's (1788-1853) "Handbuch der anorganischen Chemie", first published in two volumes (1817-19) and subsequently greatly expanded. Other important books by Thomson include his (1812) "History of the Royal Society (of London)" and his (1830-31) two-volume "History of Chemistry", the latter long comprising the only such book in English.

During his residence in London, Thomson founded (1813) the monthly *Annals of Philosophy* (vols. 1-16, 1813-20, continued by Richard Phillips (1778-1851) vols. 17-28, 1821-26; then merged into the *Philosophical Magazine*) [for history of latter see its special separate Commemoration Number *1948,* pp 1-9]. In addition to original articles this journal introduced many novel features including abstracts and critical annotations of European research, and the first annual reports on the progress

of science, particularly chemistry. After the publication of his "History of Chemistry", Thomson concentrated his writing on biographical accounts of important European and British chemists, most of which were published in the *Annals of Philosophy*.

In addition to his extensive writing and editing, Thomson carried out a large amount of experimental work and his published papers comprise 201 titles. He discovered (1803) sulfur (mono) chloride and gave (1808) the first example of the Law of Multiple Proportions by showing that in the normal and acid oxalates of potassium and strontium, one salt contains (for the same amount of acid) just double the proportion of base contained in the second. He was the first to describe (1804) the determination of the density of a solid by flotation in a liquid [cf. J. Chem. Education *25,* 307 (1948)], thus anticipating the use of this method by Davy [Phil. Trans. *98,* 21 (1808)] or by DuFour [Compt. rend. *50,* 1039 (1860), *54,* 1079 (1862)]. He introduced [Nicholson's J. *8,* 280 (1804)] the names protoxide, deutoxide, tritoxide, and peroxide. The claim that Thomson was first to introduce chemical symbols is unfounded but he may have been first (1808) to use chemical symbols in a quantitative sense [cf. J. Soc. Chem. Ind. *55,* 759-762 (1936)].

B Ann. Sci. *6,* 115-126 (1949): P_1B Chymia *1,* 37-53 (1948) (incl. bibliography of publications on history of chemistry): P_3 J. Chem. Education *9,* 871 (1932): B Dict. Natl. Biog. *56,* (1898).

Wheatstone, (Sir) Charles

Born Feb. 6,* 1802, at Gloucester, Gloucestershire, England; died Oct. 19, 1875, at Paris, France, age 73.

This British inventor and physicist, an uncle of Oliver Heaviside (1850-1925), and one of the most versatile and productive minds of the 19th century, left behind him a long record of valuable practical and scientific accomplishment in the fields of sound, light, and electricity. Little is known of his early life. He was the son of a music seller and together with a brother established in London (1823) at the age of 21 a busi-

* The day of Wheatstone's birth, not previously reported in the literature, was kindly supplied for this article by Dr. D. C. Martin from records of the Royal Society of London.

ness devoted to the making of musical instruments. Although he appears never to have had any formal college training, his scientific and technical accomplishments during the next decade attracted such favorable attention that he was appointed (1834) professor of natural philosophy at King's College, London. Owing, however, to an almost morbid timidity in the presence of an audience, an idiosyncrasy which persisted throughout his life, Wheatstone's connection with this post was largely nominal, and many of his inventions were made public through the mouth of his friend Michael Faraday (1791-1867). Nevertheless, Wheatstone ultimately bequeathed to the college his collection of books and instruments, now preserved in its Wheatstone Laboratory. Despite his lack of formal scientific preparation or college degree, his work was recognized by his election (1836) to the Royal Society of London, from which he afterward also was twice (1840, 1843) awarded a Royal Medal and later (1868) the Copley Medal, its highest honor. He was knighted in the same year (1868) and became soon after (1873) a Foreign Associate of the French Academy of Sciences. At the time of his death he held 34 distinctions from governments, universities, or learned societies in 13 countries, including honorary degrees from both Cambridge and Oxford.

Wheatstone's earliest achievements were in the field of acoustics. He first attracted attention (1821) at the age of 19 with his "Enchanted Lyre", essentially a simple device for the emission of music transmitted to it through a steel rod from its point of origin some distance away. Two years later (1823) he published his first scientific paper, dealing with certain of his acoustic experiments, in the new journal [Annals of Philosophy, (New Series) *6*, 81-90 (1823)] established (1813) by Thomas Thomson (1773-1852). He invented (1827) a device for rendering sound vibrations visible which he designated as a "Kaleidophone", and in the same year was first to employ the word "microphone" in connection with a device for the amplification of feeble sounds. He invented and patented (1829) the musical instrument known as the concertina in the same year as that in which the accordion was invented on the Continent. His principal contribution to scientific acoustics, however, is a memoir [Phil. Trans. Roy. Soc. (London) *1833*, 593-634]in which he first accounted for the formation of the beautiful and varied patterns produced in thin layers of sand by the vibration of a violin bow against the edge of the supporting surface, which having initially been observed by Ernst Florens

Friedrich Chladni (1756-1827) are still known as Chladni's figures.

Wheatstone also made memorable contributions to optics. He was first (1833) to analyze binocular vision and to construct [Phil. Trans. Roy. Soc. (London) *1838,* 371-394; Poggendorf's Ann. Physik *51,* (Suppl.), 1-48 (1839); Ann. chim. phys. (2) *2,* 330-370 (1841)] the now well-known instrument which he named stereoscope. The concept of solidity as derived from mental superposition of two pictures of the same object in dissimilar perspectives is solely due to Wheatstone and it was for his studies of binocular vision that he received (1840) his first Royal Medal. While Wheatstone's instrument was of the reflecting type, (Sir) David Brewster (1781-1868) subsequently effected further developments by employing in his refracting or lenticular stereoscope wedge-shaped segments of large lenses in which the lens and prism arrangement of Wheatstone were combined. [The relevant papers of Wheatstone, Brewster, and others on this topic have been brought together in No. 168 (1908) of the series by Wilhelm Ostwald (1853-1932) known as "Klassiker der Exakten Wissenschaften".] Wheatstone was also first (1835) to discover [Brit. Assoc. Rept. for *1835,* Part 2, 11-12; Poggendorf's Ann. Physik *36,* 148-149 (1835)] that the spectrum emitted by the incandescent vapor of metals volatilized by an electric discharge could be resolved into a series of bright lines characteristic of the metal, and to recognize the outstanding importance of this method of spectroscopic analysis subsequently further developed by Robert Wilhelm Bunsen (1811-1899), Gustav Robert Kirchhoff (1824-1887) and others. Wheatstone further devised [Brit. Assoc. Rept. for *1848,* Part 2, 10-12] a "polar clock" capable of determining true solar time, even when the sun itself was obscured, by utilizing (Sir) David Brewster's discovery that the plane of polarization of light from the sky is always 90° from the sun.

Despite Wheatstone's notable contributions to our knowledge of sound and light, some examples of which have just been mentioned, his greatest accomplishments were in the field of electricity. He was first (1834) to measure the speed with which electricity travels through a wire, obtaining a value of 288,000 miles per second. For his experiments [Phil. Trans. Roy. Soc. (London) *1834,* 583-591; Poggendorf's Ann. Physik *34,* 464-480 (1835)] to this end he devised a revolving mirror technique afterwards advantageously employed by Jean Bernard Léon Foucault (1819-1868), Armand Hippolyte Louis

Fizeau (1819-1896), and others, in the measurement of the velocity of light. Although Wheatstone did not invent the electric telegraph and indeed a score of precursors [for tabulation see Telegraphic Journal citation at end] were even then known, he together with his partner Dr. (later Sir) William Fothergill Cooke (1806-1879) were the first to develop it to a practical means of communication, and this fact was recognized in their (1837) British patent. This development went through many stages and controversies which cannot here be detailed, but included the alphabetical dial telegraph (1840), a type printing instrument (1841), the five needle, two needle and finally the single needle instrument (1845) which made its adoption practical. [For many further details see also Nature *11*, 390-392, 450-452, 470-472, 510-512 (1875); *12*, 30-32, 69-72, 110-113, 149-151, 254-256, (1875); J. Roy. Inst. Gt. Brit. *9*, 297-304 (1880).] He devised (1837) a magneto-electric generator employed with his telegraph, and (1840) a method for electrical synchronization of a series of clocks from a standard monitor. He devised and named [Proc. Roy. Soc. (London) *4*, 469-471 (1843)] the rheostat. His name is perhaps most firmly associated with that fundamental instrument for the measurement of electrical resistance which has become known as the "Wheatstone bridge". As Wheatstone himself carefully pointed out, this was initially described in the Bakerian Lecture [Phil. Trans. Roy. Soc. (London) *123*, 95-142 (1833)] of Samuel Hunter Christie (1784-1865), but its utility was popularized by Wheatstone, with whose name it has subsequently been connected. Protracted experiments on the generation of electricity culminated (1867) in the development of a dynamo in which permanent magnets were first replaced by self-exciting electromagnets. Essentially the same discovery had independently been made by Werner Siemens (1816-1892) and both papers were by coincidence read to the Royal Society on February 4, 1867, at the same meeting.

The achievements touched upon in the preceding paragraphs represent only a few of Wheatstone's contributions to the advancement of knowledge. Other interesting items include the invention (1840) of a "chronoscope" for measuring and recording very small intervals of time such as required in studying the velocity of projectiles; an electromagnetic counter for automatically recording any given repeated mechanical action; a device for automatic periodic recording of barometric pressure; a cryptographic machine for ciphering and decoding messages;

the first effective magnetoelectric machine for detonating explosive charges at a distance even under water; and many others.

More extensive accounts of Wheatstone's career may be found in R. Appleyard's "Pioneers of Electrical Communication", Macmillan and Co., London (1930) (which also includes many photographs of his apparatus); in J. Munro's "Heroes of the Telegraph", The Religious Tract Society, London (1891); and W. T. Jeans' "Lives of the Electricians", Whittaker and Co., London (1887). All of Wheatstone's papers were posthumously brought together (1879) in a Collective Volume published by the Physical Society of London.

B Proc. Roy. Soc. (London) *24,* xvi-xxvii (1876) : P_1B Nature *13,* 501-502 (1876) : P_1B Pop. Sci. Monthly *8,* 363-365 (1876) : B Telegraphic Journal [contd. after 1891 as Electrical Review (London)] *3,* 253-257 (1875) : B J. Soc. Telegraph Engineers *4,* 319-334 (1875) : B Dict. Natl. Biog. *60,* 435-437 (1899).

WIEDEMANN, EILHARD ERNST GUSTAV

Born Aug. 1, 1852, in Berlin, Germany; died Jan. 7, 1928, at Erlangen, Germany, age 76.

This German physicist was the son of the physicist Gustav Heinrich Wiedemann (1826-1899). His mother, independently notable for the publication of several books and translations, was the daughter of the distinguished chemist Eilhard Mitscherlich (1794-1863), who died when his grandson was eleven years old. After the usual preliminary studies in the gymnasia of Basel, Braunschweig, and Karlsruhe during his father' residence at the corresponding universities, the son pursued advanced studies at the University of Heidelberg during which he sat at the feet of Robert Wilhelm Bunsen (1811-1899), Gustav Robert Kirchhoff (1824-1887), and Hermann Ludwig von Helmholtz (1821-1894). His doctoral dissertation on "The Elliptical Polarization of Light and its Relation to Surface Colors", though initiated at Heidelberg, was presented (1872) at the University of Leipzig to which his father meantime had been called. Eilhard Wiedemann's own professional career continued for 14 years at Leipzig, first as docent, later (1878-85) as extraordinary professor. He then accepted (1886) an ordinary professorship at Darmstadt but in the fall of the same

year transferred to the University of Erlangen where he remained for forty years (1886-1926) until his retirement.

In order, during the earlier stages of his own professional work, to distinguish himself independently of his famous father, Eilhard Wiedemann deliberately cultivated a technical area distinct from that of his parent. His first substantial research involved an extensive study of the specific heats of gases during which he introduced many refinements representing advances over the prior contributions of Henri Victor Regnault (1810-1878). Later he studied electric discharge through gases and found independently of, but simultaneously with, Johann Wilhelm Hittorf (1824-1919) that light was given off far below 100° C., thus demonstrating that light emission was not merely the result of heating to incandescence as had formerly been supposed. In still later work at Erlangen, Wiedemann discovered (1887) that under certain circumstances the fluorescence of dyestuffs could be extended to phosphorescence, and subsequently developed a terminology for luminescence phenomena which has achieved international acceptance.

In addition to these and other contributions to experimental physics, Eilhard Wiedemann is notable for scientific literary enterprises of two entirely different types. He founded (1877) and for 24 years (1877-1901) edited the important abstract and review journal of physics known as Wiedemann's *Beiblätter*. This publication, undertaken at the suggestion of Johann Christian Poggendorf (1796-1877), comprised a valuable adjunct to the latter's *Annalen der Physik* by directing particular attention to the work of physicists of other countries. His other literary activity was concerned with research in the history of Arabian science, an interest possibly founded on and certainly facilitated by his extraordinary linguistic powers, and regarding which he published more than 250 contributions. (For a complete bibliography of these papers, see the Isis reference below.)

P_1B Isis *14,* 166-186 (1930) : B Physik Z. *29,* 185-190 (1928).

For the convenience of users, the names of the 103 persons whose biographical digests have appeared in this and the three preceding annual series are here tabulated with reference to the year of the particular article of this series in which their anniversaries were cited.

Anschütz, R.	1952
Balard, A. J.	1952
Becquerel, A. H.	1952
Berliner, E.	1951
Bernouilli, D.	1950
Billeter, O.	1951
Black, J.	1949
Boussingault, J. B.	1952
Braun, K. F.	1950
Brφgger, W. C.	1951
Brühl, J. W.	1950
Claisen, L.	1951
Clapeyron, B. P. E.	1949
Dana, E. S.	1949
Daguerre, L. J. M.	1951
De La Rive, A. A.	1951
Del Rio, A. M.	1949
Demarcay, E. A.	1952
Descartes, R.	1950
Dixon, H. B.	1952
Dobbie, Sir J. J.	1952
Döbereiner, J. W.	1949
Doebner, O. G.	1950
Dumas, J. B. A.	1950
Étard, A. L.	1952
Eykman, J. F.	1951
Fischer, E.	1952
Fischer, O. P.	1952
Fleming, Sir J. A.	1949
Frasch, H.	1951
Gabriel, S.	1951
Gadolin, J.	1952
Gay-Lussac, J. L.	1950
Goldschmiedt, G.	1950
Goldstein, E.	1950
Gooch, F. A.	1952
Goodyear, C.	1950
Guericke, O. von	1952
Haller, A.	1949
Heaviside, O.	1950
Hell, C. M. von	1949
Hempel, W. M.	1951
Henniger, A. R. M.	1950
Hepp, E.	1951
Herreshoff, J. B. F.	1950
Hess, G. H.	1950, 1952
Hill, H. B.	1949
Hoff, J. H. van't	1952
Hofmeister, F.	1950
Hummel, J. J.	1950
Jacobi, K. G. J.	1951
Jacobi, M. H.	1951
Jenner, E.	1949
Jones, W.	1949
Kingzett, C. T.	1952
Kjeldahl, J. G. C. T.	1949
Klein, C. F.	1949
Koenigs, W.	1951
Laplace, P. S.	1949
Lassaigne, J. L.	1950
LeChatelier, H. L.	1950
Legendre, A. M.	1952
Lodge, Sir O. J.	1951
Maberry, C. F.	1950
Magnus, H. G.	1952
McMurtrie, W.	1951
Meldola, R.	1949
Michelson, A. A.	1952
Miller, W. H.	1951
Moissan, H.	1952
Munroe, C. E.	1949
Napier, J.	1950
Nichols, W. H.	1952
Noelting, D. E.	1951

Oersted, H. C.	1951
Osler, Sir W.	1949
Pavlov, I. P.	1949
Pechmann, H. von	1950
Plücker, J.	1951
Poynting, J. H.	1952
Ramon y Cajal, S.	1952
Ramsay, Sir W.	1952
Reich, F.	1949
Reverdin, F.	1949
Richet, C. R.	1950
Rutherford, D.	1949
Saussure, H. B. de	1949
Schönbein, C. F.	1949
Schultz, G.	1951
Schuster, Sir A.	1951
Skraup, Z. H.	1950
Stillman, J. M.	1952
Talbot, W. H. F.	1950
Thompson, S. P.	1951
Thomson, T.	1952
Vaughan, V. C.	1951
Wagner, G.	1949
Welch, W. H.	1950
Weston, E.	1950
Weyl, T.	1951
Wheatstone, Sir C.	1952
Wiedemann, E.	1952
Wöhler, F.	1950

100